United States General Accounting Office

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Report to the Chairman, Committee on Armed Services, U.S. Senate

DEFENSE ACQUISITION PROGRAMS

Status of Selected Systems

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National Security and International Affairs Division

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December 14, 1989

The Honorable Sam Nunn
Chairman, Committee on Armed Services
United States Senate

Dear Mr. Chairman:

In response to your request, we reviewed the requirements, schedule, performance, cost, and funding support for 13 defense acquisition programs. In consultation with your Office, we selected programs[1] that were scheduled for an acquisition milestone decision during fiscal year 1990 or 1991 and that were possible candidates for milestone authorization.[2] During our review, the services revised the scheduled milestone authorization dates for some programs beyond fiscal year 1991; however, we retained these programs in our review.

We pursued the following lines of inquiry in evaluating the 13 acquisition programs:

- Has consensus been reached within the service and the Office of the Secretary of Defense that there is a valid requirement for the program and that the program represents the best solution?
- Do service assessments indicate that the program represents a significant increase in capability over current capabilities?
- Do past or anticipated schedule slippages indicate whether the risk of meeting the program schedule is low to moderate?
- Has the program's demonstrated performance shown whether it will meet requirements or are there indications of significant technical obstacles to achieving desired performance?
- Has the program experienced cost growth or are there indications of future cost growth that would indicate whether estimates of future costs are reliable?

[1] The terms program and system both refer to an individual weapon system acquisition program and are used interchangeably in this report.

[2] Milestone authorization means that funding would be authorized to cover the entire acquisition phase—but not to exceed 5 years—for either full scale development (milestone II) or full rate production (milestone IIIB).

The programs we reviewed and the next milestone decision[1] for each program, current as of July 1989, are shown in table 1.

Table 1: Milestone Decisions for 13 Programs

Acquisition program	Milestone decision	Date
Army programs		
Advanced Antitank Weapon System Heavy (AAWS-H)	II	Aug. 1990
Light Helicopter (LHX)	II	[illegible]
Multiple Launch Rocket System-Terminal Guidance Warhead (MLRS TGW)	II	Apr. 199[illegible]
Line-of-Sight Forward Heavy (LOS-F-H)	IIIA	June 199[illegible]
Navy programs		
Rolling Airframe Missile (RAM)	IIIB	Aug. 1990
V-22 Osprey Aircraft[a]	IIIA	Dec. 1989
Sea Lance Antisubmarine Warfare Standoff Weapon	IIIA	June 1992
AN/BSY-1 Submarine Combat System	IIIB	Oct. 1990
Air Force programs		
Peacekeeper Rail Garrison	IIIA	Apr. 1990
Advanced Tactical Fighter (ATF)	II	Dec. 1990
Sensor Fuzed Weapon (SFW)	IIIA	Jan. 1990
NAVSTAR Global Positioning System User Equipment (GPS UE)	IIIB	June 1990
Tacit Rainbow		
ground-launched	II	Sept. 1989
air launched	IIIA	1991[b]

[a] In the fiscal year 1990 amended budget request, the Department of Defense (DOD) recommended terminating this program.

[b] Decision expected during first quarter of 1991.

Results in Brief

While all of the 13 programs are being developed to satisfy a stated military requirement, given current budget constraints, there is not full agreement within DOD that certain programs represent the best or most cost-effective solution for satisfying the requirement. This is particularly true of the $25.9 billion V-22 Osprey aircraft program. Although a high priority Marine Corps program, the Secretary of Defense deleted it

[1] Major acquisitions typically proceed through four milestone decisions. At milestone 0, mission need is established and alternative system concepts identified. Milestone I starts the demonstration and validation phase during which a few test articles are fabricated. A milestone II decision authorizes full scale development, and milestone III is the production decision. This may be divided into two increments—milestone IIIA (low rate initial production) and milestone IIIB (full rate production).

from the amended fiscal year 1990/1991 budget because existing aircraft were judged to be more cost-effective for accomplishing the V-22's primary mission. Also, although the Army's $40.5 billion LHX program is expected to offer significant increases in capability over existing helicopters, its specific requirements are not yet firm and the Army does not know whether this aircraft represents the most cost-effective way to accomplish the LHX's projected missions.

Consensus is also lacking on whether portions of the Tacit Rainbow and the AAWS-II programs represent the best solutions for satisfying stated requirements. The Air Force's decision to drop out of the ground-launched version of Tacit Rainbow—an enemy air defense suppression program—and the Navy's decision to drop out of the air-launched program, both for budgetary reasons, prompted DOD to begin reassessing enemy air defense suppression requirements.

The future of the Army's AAWS-II program to develop two antitank missile systems is also unclear. The estimated cost for developing a prototype of the Line of Sight Antitank (LOSAT) portion of the program has increased from $10 million to $118.4 million, with no current cost estimates for production, and a firm decision has not been made on the configuration or technologies to be pursued for developing the Advanced Missile System-Heavy (AMS-H) portion of the program. Also, the current funding plan is inadequate to finance development of both LOSAT and AMS-H. Although Army officials stated that AAWS-II is one of the Army's highest priority programs, this program has absorbed most of the reductions to the antitank weapons systems budget line.

Each of the 13 progra[illegible]s experienced schedule slippages; cost estimates have increased fo[illegible]of the programs; and program changes resulting from schedule slippages, budget cuts, and technical problems suggest the potential for future cost growth for 7 programs. In some cases, projected procurement quantities were reduced to avoid excessive program cost growth. For example, the Army cut the quantity of LHXs to be procured by over 50 percent to keep cost growth in check and to absorb budgetary reductions, but, even with this quantity reduction, it is unlikely that the Army will have the money to sustain its currently planned peak production rate of 216 aircraft per year. The Army also cut the number of TGW-equipped rockets to be procured by 50 percent; a program that has already had its production schedule delayed more than 5 years, including a 3-year delay in validating whether the weapon will work as intended.

The Navy's RAM program has also had a history of schedule slippages, technical problems, and cost growth. The Navy formally identified a requirement for a new self-defense system in late-1973. Full-scale development, initially expected to take about 56 months when this phase began in 1979, is now expected to take more than 11 years. Although initially intended to be a low cost system, the estimated per unit cost has grown from \$57,000 to \$166,000, and this is without the capability to counter the more modern antiship missiles with nonradiating guidance systems or very low flying sea skimmer-type missiles. While early testing of the RAM ended in failure, initial operational tests conducted in late 1986 through early 1987 were judged to be successful. However, test limitations, such as the inability to test against targets that fully simulated the threat, continue to hamper assessment of RAM performance.

The Navy's \$4.7 billion AN/BSY-1 submarine combat system has also faced schedule slippages and cost growth, and delays in delivering the initial system to the shipbuilder resulted in shipbuilder claims against the government. The first four systems delivered will give the submarines on which they are to be installed only a self-defense capability, no offensive capability. A subsequent upgrade to these four systems is intended to provide the offensive capability.

Navy officials expressed confidence that once the AN/BSY-1 system is complete it will be an improvement over existing systems, and preliminary subsystem testing supports this view; however, the Navy will not know for sure until operational testing and evaluation is completed in early 1991. By that time all 24 systems will have been purchased.

Although the full operational capability schedule for the Air Force's Peacekeeper Rail Garrison system has slipped by 6 months—to June 1994—this schedule appears optimistic because it requires an ambitious development schedule to perform all the activities needed to support deployment. Also, it requires the start of production after completing only 2 years of the 4-year developmental program. As demonstrated by other Air Force acquisition programs, unless such concurrency is well planned and controlled, it can cause cost, schedule, and performance problems.

The Air Force's schedule for its \$67.1 billion ATF program also provides for some concurrent development and production, but the new program schedule, revised to accommodate the President's amended fiscal year 1990/1991 budget, reduced risks associated with concurrency. Had the

earlier schedule been followed, a contract for the first production lot of 18 aircraft would have been awarded at the same time full-scale development flight testing began. Now the schedule calls for the first production contract to be awarded 5 months before flight testing begins, but only 4, rather than 18, aircraft will be committed to production. Contracting for subsequent production lots is also scheduled to reduce concurrency risks. Nonetheless, achieving the desired ATF performance capabilities, while remaining within cost goals, will be a challenge for the Air Force because of the risks associated with technological advances.

Table 2 briefly summarize the results of our review for each of the 13 systems. Detailed information on the Army, Navy, and Air Force systems reviewed is provided in appendixes I through III.

Table 2: Status of the Programs Reviewed

Program	Recent schedule slippage	Future slippage indicated	Demonstrated it will meet requirements	Recent cost growth	Future cost growth indicated
In early development					
MLRS TGW	Yes	Yes	Unknown[b]	Yes	Yes
AAWS-H	Yes	Yes	Unknown[b]	Yes	Yes
LHX	Yes	Yes	Unknown[b]	Yes	Yes
ATF	Yes	Unknown	Unknown[b]	No	Unknown
In full scale development					
V-22	Yes	Yes	Partial	Yes	Unknown
SFW	Yes	Yes	Partial	Yes	Yes
Sea Lance	Yes	No	No	Yes	Yes
Rail Garrison	Yes	No	Unknown[b]	No	No
Tacit Rainbow[a]	Yes	No	No	Yes	Unknown
In production					
LOS-F-H	Yes	Yes	Partial	Yes	Yes
NAVSTAR GPS UE	Yes	Unknown	Partial	No	No
RAM	Yes	Yes	Unknown[c]	Yes	Yes
AN/BSY-1	Yes	No	Partial	Yes	No

[a]This reflects the status of the air launched version, the ground launched version is in early development and there are many unknowns

[b]Testing has not begun

[c]Testing has not been adequate to assess whether the system will meet requirements

The cost estimates for the 13 programs reviewed, based on information provided by DOD, are shown in tables 3 through 5.

Table 3: Cost Estimates for Programs in Early Development (Escalated Dollars)

Dollars in millions

Program	Early development cost	Full-scale development cost	Production cost	Total cost
MLRS TGW	$304.2	$183.0	$6,810.3	**$7,297.5**
AAWS-H	149.1	1,101.3	a	**a**
LHX	1,000.0	2,900.0	36,600.0	**40,500.0**
ATF	3,300.0	9,300.0	52,200.0	**64,800.0**

[a]The Army does not have a production cost estimate for this program

Table 4: Cost Estimates for Programs in Full-Scale Development (Escalated Dollars)

Dollars in millions

Program	Development cost	Initial production cost	Full-rate production cost	Total cost
Sea Lance	$1,083.1	$394.4	$1,866.5	**$3,344.0[a]**
Peacekeeper Rail Garrison	2,600.0	b	3,500.0	**6,800.0[c]**
V-22	2,660.5	5,622.2	17,572.7	**25,855.4**
SFW	180.0	608.0	2,423.0	**3,211.0**
Tacit Rainbow[d]	165.2[e]	f	f	**3,319.7[f]**

[a]Includes military construction

[b]Not available

[c]Includes about $700 million for military construction

[d]Air-launched system estimate only (not including classified amounts). Estimated total cost of the ground-launched system is about $1.6 billion

[e]Includes only funds for fiscal years 1988-92. Prior year funding amounts are classified

[f]Includes procurement of missiles, aircraft launcher modifications, and military construction

Table 5: Cost Estimates for Programs in Production (Escalated Dollars)

Dollars in millions

Program	Development cost	Initial production cost	Cost for 5 years full-rate	Cost to complete	Total cost
LOS-F-H[a]	$265.9	$142.0	$2,094.2	$4,299.9	**$6,802.0**
Navstar GPS UE	1,215.1	756.7	1,485.8	672.4	**4,130.0**
AN/BSY-1[b]	1,211.0	2,589.5	—	924.3	**4,724.8**
RAM	232.2	218.3	647.5	529.0	**1,627.0**

[a]Cost estimate as of December 1986

[b]Includes $62.8 million for installation costs that were moved from procurement to operation and maintenance accounts in December 1988

Milestone Authorization

Legislation (10 U.S.C. 2437) enacted in October 1986 established milestone authorization to enhance program stability. The underlying principle was that if DOD would commit itself to managing a program to agreed upon cost, schedule, performance, and other requirements, the Congress would commit itself to stable multiyear funding authorization. The legislation required the Secretary of Defense to (1) designate a number of programs as "Defense Enterprise Programs" to receive streamlined management and (2) nominate selected Defense Enterprise Programs as milestone authorization candidates. A 1987 amendment enabled the House and Senate Committees on Armed Services to consider defense acquisition programs for milestone authorization that have not been designated as Defense Enterprise Programs and to approve such systems for milestone authorization as they deem appropriate.

In March 1987 the Secretary of Defense designated 10 acquisition programs as Defense Enterprise Programs and nominated 3 of these for milestone authorization—the Army Mobile Subscriber Equipment, the Navy Trident II D-5 Missile, and the Air Force Medium Launch Vehicle. The Congress approved milestone authorization for the Army and Navy systems, and two others the Congress had considered—the Navy T-45 Training System and the Army Tactical Missile System. Since then, neither DOD nor the Congress has designated or nominated systems.

In his July 1989 report to the President entitled Defense Management, the Secretary of Defense stated that DOD should take better advantage of the Defense Enterprise Program and milestone authorization than it had in the past. The report states:

"The USD A [Under Secretary of Defense for Acquisition], with the SAEs [Service Acquisition Executives], will carefully select several new Defense Enterprise Programs from programs in the DAB's [Defense Acquisition Board's] *Concept Approval* (post-Milestone I) phase, provide strong policy direction and oversight in implementing the DEP [Defense Enterprise Program] concept, and seek milestone authorization for such programs to enhance management stability."

DOD officials told us they were reviewing the Defense Enterprise Program and the related legislation and were preparing an implementation plan and a proposed list of candidate programs, which they expected to present to the Secretary of Defense by October 1, 1989.

Objectives, Scope, and Methodology

Our objectives were to assess the status of programs that were scheduled for full-scale development or production decisions during fiscal year 1990 or 1991 and to provide information the Committee may wish to consider in determining whether to grant milestone authorization for a particular program. We selected systems with acquisition milestones scheduled for fiscal year 1990 or 1991; however, during our review, several of the scheduled decision points were postponed to later years.

To obtain this information, we reviewed relevant program documents such as operational requirements, selected acquisition reports, operational effectiveness analyses, contract documents, and budget exhibits. We also interviewed responsible DOD and military service program officials. In addition, we had ongoing reviews in seven of the selected programs, which we drew upon for this review. The majority of our work was done before the amended budget was presented in April 1989 by President Bush, but we did follow-up work to determine the extent to which the proposed $10 billion budget reduction affected the programs we reviewed. Almost all the programs reviewed were affected to some extent by the budget change.

We conducted our work at headquarters, Departments of the Army, Navy, and Air Force at the Pentagon, Washington, D.C.; Army Aviation Systems Command, St. Louis, Missouri; Army Missile Command, Huntsville, Alabama; Army Materiel System Analysis Activity and Ballistic Research Laboratory at Aberdeen Proving Ground, Maryland; Air Force Systems Command, Space Division, Los Angeles, California; Aeronautical Systems Division, Wright Patterson Air Force Base, Ohio; Armament Division, Eglin Air Force Base, Florida; Naval Sea Systems Command and Naval Air Systems Command, Arlington, Virginia; Naval Air Development Center, Warminster, Pennsylvania, Naval Underwater Systems

Center, New London, Connecticut; and Navy Operational Test and Evaluation Force, Norfolk, Virginia.

As requested, we did not obtain official agency comments; however, we did discuss the report's contents with DOD and program officials whose comments were incorporated in the report. Our work was performed from October 1988 to July 1989 in accordance with generally accepted government auditing standards.

We are sending copies of this report to the Chairmen, House Committees on Armed Services and on Government Operations, House and Senate Committees on Appropriations, and Senate Committee on Governmental Affairs; the Secretary of Defense; the Secretaries of the Army, Navy, and Air Force; and the Director of the Office of Management and Budget. Copies will be made available to other interested parties upon request.

This report was prepared under the direction of Harold J. Johnson, Issue Area Director, National Security and International Affairs Division, who may be reached on 275-5790 if you or your staff have any questions. Other major contributors are listed in appendix IV.

Sincerely yours,

Frank C Conahan

Frank C. Conahan
Assistant Comptroller General

Contents

Figures

Abbreviations

AAWS-H	Advanced Antitank Weapon System-Heavy
ADATS	Air Defense Antitank System
AMS-H	Advanced Missile System-Heavy
ASW	Antisubmarine Warfare
ATF	Advanced Tactical Fighter
CAIG	Cost Analysis Improvement Group
DOD	Department of Defense
FAADS	Forward Area Air Defense System
FY	Fiscal Year
FOG-M	Fiber Optic Guided Missile
GAO	General Accounting Office
GPS	Navstar Global Positioning System
IBM	International Business Machines
ICBM	Intercontinental Ballistic Missile
LHX	Light Helicopter
LOS-F-H	Line-of-Sight Forward Heavy
LOSAT	Line of Sight Antitank
MLRS	Multiple Launch Rocket System
NATO	North Atlantic Treaty Organization
OSD	Office of the Secretary of Defense
RAM	Rolling Airframe Missile
SAR	Selected Acquisition Report
SFW	Sensor Fuzed Weapon
TGW	Terminal Guidance Warhead
TOW	Tube Launched, Optically Tracked, Wire Guided Missile System

Army Programs

Advanced Antitank Weapon System-Heavy

The Advanced Antitank Weapon System-Heavy (AAWS-H) is the Army's program to develop a family of missile systems to defeat modern tanks and other armored targets expected on the battlefield of the 1990s. Its systems are to replace the Tube-Launched, Optically-Tracked, Wire-Guided (TOW) missile system and provide increased lethality and range.[1] The AAWS-H program consists of the Line of Sight Antitank (LOSAT) and the Advanced Missile System-Heavy (AMS-H) missile systems, which are in an early stage of development, with a full-scale development decision scheduled for August 1990. LOSAT and AMS-H, as proposed, will consist of a missile, a fire control system, a platform, and a launcher. However, the systems will differ in seeker and guidance technology and operational characteristics.

The Army estimates total development of both missile systems to cost $1,250.4 million (escalated dollars), but it does not have a current estimate of the production costs. Army plans call for LOSAT to replace only the improved TOW vehicle, which represents 21 percent of all TOW systems. AMS-H would replace all other TOW systems, if it is developed.

LOSAT and AMS-H project management officials do not report any significant schedule or performance problems to date, but they assess overall schedule risk as high for LOSAT due to a compressed time frame for development completion. A performance risk assessment, based on tests, is not feasible at this time because critical tests have not begun. However, the Army is considering changes in the acquisition strategy for both LOSAT and AMS-H that would delay development and reduce overall risk but would increase costs for the current phase.

Background

Until April 26, 1989, the Army managed LOSAT and AMS-H jointly. At that time, the Army initiated separate management of the two systems, but it maintained common requirements and justification documentation.

Line of Sight Antitank System

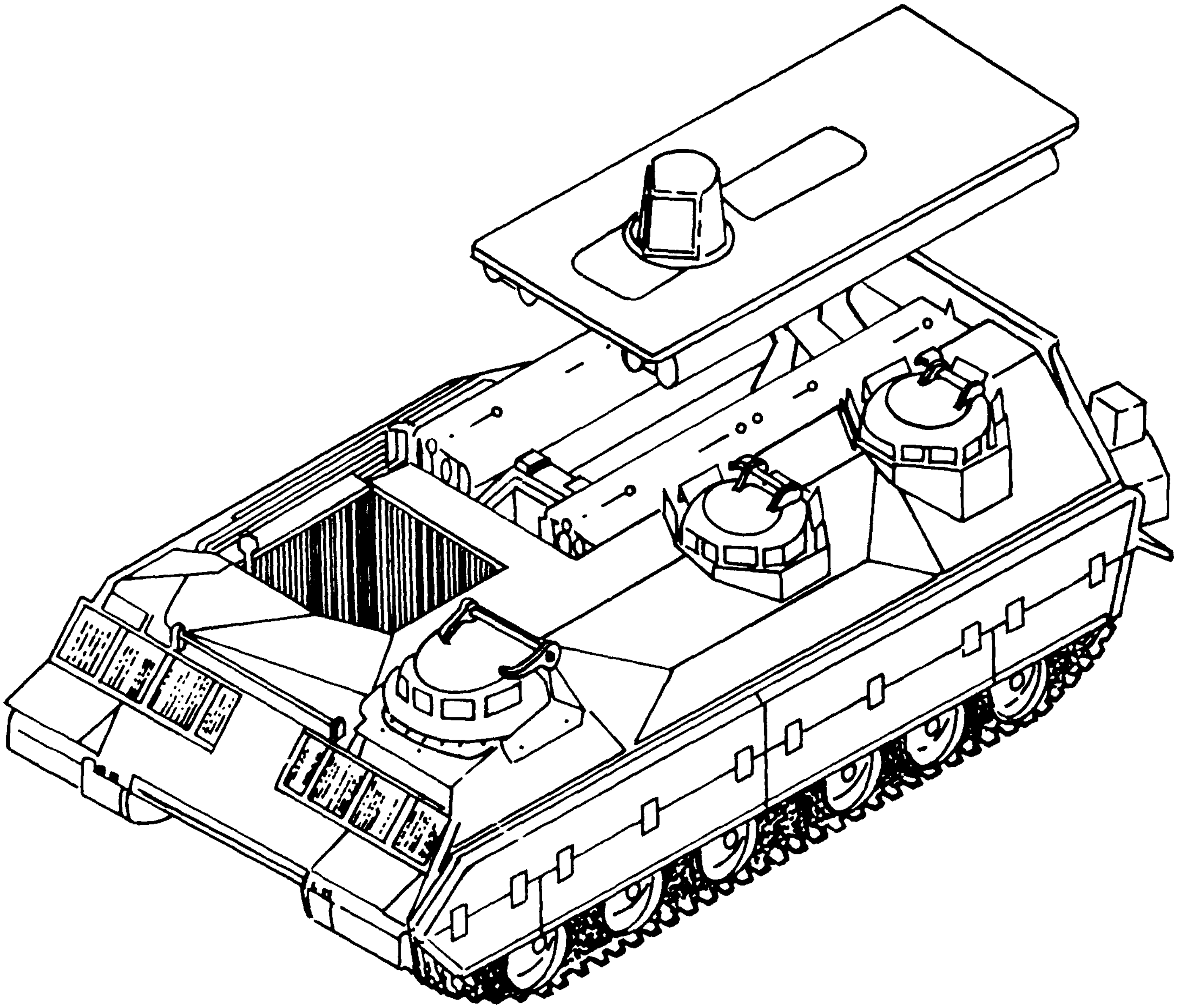
LOSAT will be equipped with the Kinetic Energy Missile—a missile that uses very high speed and a heavy metal rod to penetrate threat armor. Its fire control system will use an infrared sensor to detect and track targets and a laser device to transmit guidance updates to the missile. When a missile flies into the infrared sensor's field of view, the sensor will track both target and missile. The fire control system will compute

[1] The Army uses the TOW on the Cobra helicopter, the Improved TOW vehicle, the M151 jeep, the Bradley fighting vehicle, the armored personnel carrier, and the high mobility multipurpose wheeled vehicle.

the difference in position between the missile and the target and send missile corrective guidance updates by means of a pulsed laser signal. LOSAT will be carried on a Bradley-type vehicle modified to incorporate the fire control system and the Kinetic Energy Missile. Army plans call for LOSAT to replace only the improved TOW vehicle. During the proof of principle phase, the Army intends to develop early prototypes of the fire control system and the Bradley modification. A representation of LOSAT is presented in figure I.1.

Proof of principle is an early developmental stage during which the Army documents plans for later phases, verifies preliminary design and engineering concepts, and validates technology and components. In this program, it leads to milestone II — full-scale development — decision.

Figure I.1: Representation of LOSAT



Advanced Missile System-Heavy

The Army has not selected the specific configuration for AMS-H. Therefore, during the proof of principle phase, the Army will evaluate

imaging infrared seeker technologies used to detect and acquire targets and to guide the missile to impact. It also will evaluate for possible application to the AMS-H missile (1) emerging missile technologies and (2) technologies in development for the Advanced Antitank Weapon System-Medium or a TOW modification. The Army's AMS-H deployment plans call for the replacement of TOW on the Bradley fighting vehicle, the high mobility multipurpose wheeled vehicle, and, possibly, the Cobra helicopter.

During the full-scale development phase, the Army may develop an improved fire control system for use with either or both the AMS-H or the TOW missile, which would extend missile range in an operational environment and provide a greater rate of kill. According to an AMS-H project management official, the Army could develop the improved fire control system without developing other AMS-H components to enhance TOW capabilities.

Requirements

The Army established its need to replace the TOW systems in a July 1986 AAWS-H justification for major system new start document and in an October 1988 AAWS-H operational and organizational plan. These documents describe the AAWS-H replacement for TOW as up to a two-system family. However, planned development funding will limit full-scale development to a single system. The Army's preferred system—LOSAT—would replace only the improved TOW vehicle or about 21 percent of the existing TOW systems.

Both the operational and organizational plan and the justification document describe the capability needed to replace the TOW system while continuing to use existing TOW platforms. AMS-H, if developed, would replace the majority of the TOW missiles, with LOSAT as a complementary system.

Currently planned funding, however, will not support full-scale development of both LOSAT and AMS-H and could limit the replacement of TOW systems. Because of a $581.2 million shortfall in planned AAWS-H development funding, the Army established full-scale development funding priorities within the AAWS-H program. For reasons that are classified, the Army designated LOSAT as first priority, the improved fire control system (for either AMS-H or existing TOW missiles) as second, and the remaining AMS-H components as third. According to a LOSAT management official, the LOSAT platforms could replace all of the existing 2,500 improved TOW vehicles, which would leave at least 9,500 other TOW platforms and their associated TOW missiles deployed. The third

priority—AMS-H—is the Army's potential replacement for the remaining 9,500 platforms.

According to a LOSAT project management official, the projected shortfall will cause the Army to evaluate relative progress of both LOSAT and AMS-H prior to the AAWS-H full-scale development decision. If LOSAT's progress is satisfactory, the Army will proceed with LOSAT into full-scale development. If its progress is unsatisfactory, the Army will consider full-scale development of the improved fire control system and the other AMS-H components.

Schedule

LOSAT and AMS-H are in the proof of principle phase, and the Army plans a full-scale development decision in August 1990. LOSAT and AMS-H project management officials report no slips in critical milestones to date. (See table I.1 for the AAWS-H schedule.) However, they assess the development schedule risk as high for LOSAT and as moderate to moderately high for AMS-H.

Table I.1: Current AAWS-H Schedule

Event	Date
LOSAT prototype proof of principle contract award	Apr 1988
Imaging infrared seeker technical demonstration contract award	Mar 1989
Full-scale development decision	Aug 1990[a]
Initial low-rate production contract award	Oct 1993
Operational testing begins	Jan 1994
Operational testing ends	Mar. 1994
First unit equipped	Oct - Dec. 1994
Full-rate production decision	Apr. - June 1995
Initial operational capability	Classified

[a]The Army's current schedule, beginning with the full-scale development decision, may apply to either LOSAT or AMS-H. The Army has not defined an alternative development schedule for the system not selected.

A LOSAT management official believes that LOSAT's schedule risk is high because of the limited amount of time available to demonstrate that the missile system is ready for full-scale development and the compressed time frame in which to complete development. An AMS-H project management official assesses schedule risk for AMS-H as less than that for LOSAT because of experience with the AMS-H type technologies in the Advanced Antitank Weapon System-Medium and other programs. However, he added that risk could be moderate to moderately high depending on

whether the Army exercises a contract option for a risk reduction effort for AMS-H.

Performance

The AAWS-H systems are in early development and program development testing has not begun, but, in a separate effort, the Army participated in a series of joint service Hypervelocity Missile (another term for the Kinetic Energy Missile) tests. On the basis of program test results, an assessment of the program's performance is not feasible at this time, but LOSAT and AMS-H project management officials currently assess LOSAT's technical risk as high and AMS-H's risk as moderate. Reports on LOSAT prototype and AMS-H imaging infrared seeker testing are scheduled for August and September 1990, respectively.

Line of Sight Antitank System

The Army awarded a LOSAT prototype development contract to LTV Aerospace and Defense Company in April 1988 to begin (1) development of the Kinetic Energy Missile and the fire control system and (2) integration of the missile and the fire control system into the vehicle. Testing during prototype development will include 18 flights to test improved acquisition, seeker, and tracking technologies. These tests will be conducted between September 1989 and April 1990. The Army expects to use the prototype LOSAT vehicle and the fire control system for the last 10 flight tests. A LOSAT project management official assesses the technical risk as high for development of the LOSAT prototype due to the compressed time frame for development. The Army expects to complete prototype development and testing by May 1990 and to issue its report in August 1990.

Apart from the AAWS-H program, the Army participated in an Air Force led joint service Hypervelocity Missile ground launch demonstration program. On the basis of four tests, the Army project manager believes that the testing successfully demonstrated missile guidance and control, tracking, and high speed flight. According to the project manager, testing did not reveal technological problems that would prevent the missile's further development in the LOSAT program.

Advanced Missile System-Heavy

The Army awarded contracts to Hughes Aircraft Company and Texas Instruments, Incorporated, in March 1989 to begin designing an imaging infrared seeker that can lock on to a target before missile launch and engage it at extended range. The 18-month technical demonstration for the seeker includes captive flight testing, beginning in March 1990, to demonstrate the seeker's capabilities. Each of the two contracts contains an option for a risk reduction program that includes system flight tests

after the technical demonstration. According to the AMS-H deputy project manager, overall technical risk for this demonstration is moderate. The Army plans to issue a test report on the technical demonstration in September 1990.

Cost

The Army does not have an acquisition cost estimate for the current program. It estimates development of both systems to cost $1,250.4 million, but has no current estimate for production costs. The Army considers its earlier production estimate for the systems invalid, and it expects a new acquisition estimate by March 1990.

Army estimates for AAWS-H proof of principle and for full-scale development as of February 1988 and October 1988 are shown in table I.2.

Table I.2: AAWS-H Development Cost Estimates (Escalated Dollars)

Dollars in millions

Item	Feb. 1988 estimate	Oct. 1988 estimate	Change
Proof of principle			
LOSAT prototype	$10.0	$118.4	$108.4
Imaging infrared seeker technical demonstration	78.8	30.7	−48.1
Total proof of principle	**$88.8**	**$149.1**	**$60.3**
Full-scale development			
LOSAT	482.7	518.6	35.9
Improved fire control system	165.2	150.6	−14.6
AMS-H	432.1	432.1	0
Total full-scale development	**$1,080.0**	**$1,101.3**	**$21.3**
Total	**$1,168.8**	**$1,250.4**	**$81.6**

The total development estimate increased by $81.6 million between February and October 1988. According to a LOSAT project management official, the LOSAT proof of principle development cost increased by $108.4 million because the Army accelerated the LOSAT program, added the LOSAT prototype development, and increased flight testing. In addition, the Army added $35.9 million to the LOSAT full-scale development cost to cover schedule risk contingencies. These increases were offset partially by (1) eliminating AMS-H flight tests—estimated to cost $48.1 million—from the imaging infrared seeker technical demonstration program and

(2) reducing the AMS-H improved fire control system's estimated cost by $14.6 million.

According to LOSAT and AMS-H project management officials, they do not have a production estimate for the current AAWS-H systems. The Army prepared a production cost estimate, but project officials now consider it to be outdated. According to the officials, the estimate is no longer valid because (1) the program start date was delayed 1 year, (2) program priorities have shifted to LOSAT, and (3) production quantities are not defined. They stated that a new program cost estimate will be prepared by March 1990. However, the Army will not have a reliable cost projection until August 1990 when it decides which system or systems to move into full-scale development and the number of missiles to be bought.

Potential Acquisition Strategy Changes

According to project management officials, the Army is considering acquisition strategy changes for the LOSAT and AMS-H programs. The potential changes include (1) competition for the LOSAT full-scale development contract award and (2) a 2-year risk reduction effort for the AMS-H seeker. Although the Army has not approved either change, implementing these changes would delay both programs' schedules and reduce the overall risk, but costs for the current proof of principle phase would increase.

The Army requested the LOSAT project office to submit a plan for competing the full-scale development contract award. The project office submitted a plan for qualifying a competitor during the proof of principle phase and awarding the full-scale development contract on a competitive basis, but, according to a LOSAT management official, competition would delay LOSAT's full-scale development, production, and first unit equipped dates about 1 year and add about $41 million (escalated dollars) to the current phase. However, he believed that competition would reduce schedule and performance risk during full-scale development and that it could reduce the cost of full-scale development.

For AMS-H, the Army is considering exercising contract options for a risk reduction effort following the AMS-H technical demonstration. This effort would consist of flight tests to demonstrate the AMS-H seekers' range and target engagement capabilities. According to project management officials, this effort could extend the proof of principle phase by as much as 2 years but would lower overall schedule and performance risk during full-scale development. The AMS-H deputy program manager stated that this effort would add about $25 million (escalated dollars) to the current AMS-H development phase.

Program Priority and Affordability

The AAWS-H action officer at the Office of the Secretary of the Army (Research, Development and Acquisition) stated that the AAWS-H program has the same high priority within the Army as the Advanced Antitank Weapon System-Medium—the Army's highest priority system for light infantry forces. The officer added, however, that despite this, AAWS-H has absorbed the reductions to the combined budget line for the medium and heavy systems.

Projected funding shortfalls indicate that the program may be reduced further before one system is completely developed. Planned funding through full-scale development totals $669.2 million (escalated dollars), whereas estimated overall development costs for LOSAT and AMS-H are $1,250.4 million (escalated dollars)—a shortfall of $581.2 million. Because the planned development funding is greater than the Army's current cost estimates for LOSAT and AMS-H ($637 million and $613.4 million, respectively), AAWS-H full-scale development will be limited to either LOSAT or AMS-H and the improved fire control system unless current budgets are revised.

Recent GAO Reports

None.

Light Helicopter Program

The Light Helicopter (LHX) program is intended to provide the Army with a new generation of lightweight helicopters to perform both scout and attack missions. The Army estimates the program will cost $40.5 billion (escalated dollars) for 2,096 helicopters and has requested $292.4 million in the fiscal year 1990 budget to continue research and development. The Office of the Secretary of Defense (OSD) approved LHX's entry into the demonstration and validation phase in June 1988. The Army has scheduled a full-scale development decision for December 1990.

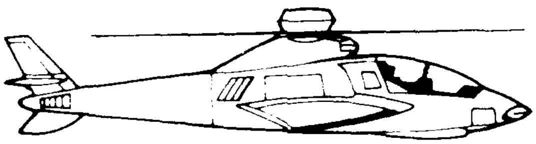
The LHX will offer a significant increase in capability over the helicopters it is to replace. However, LHX requirements are not yet firm, and whether LHX will be the most cost-effective way to meet the requirements will be determined during the demonstration and validation phase. The program faces technical risks in the form of integrating advanced technologies and controlling weight growth. Also, during the past 2 years, the Army has curbed cost growth by scaling back performance requirements and aircraft quantities, and it is continuing to review system requirements in an effort to control program costs. Despite this, potential for future cost growth exists in the form of technical risks, aircraft weight, and funding availability. For example, in 1988 OSD determined that the program was not affordable, and, as a result, the Army cut the program in half. Even with this major reduction, projected procurement funds are insufficient for planned LHX production rates.

Background

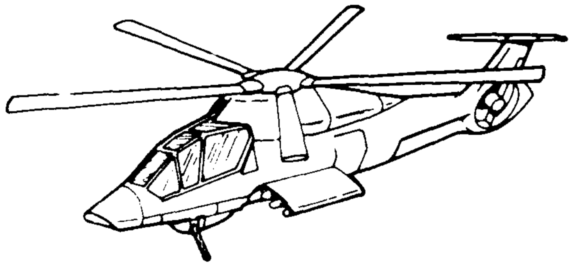
The LHX is to replace older helicopters that the Army considers no longer able to fight and survive on the battlefield. These include the AH-1S Cobra attack helicopter and the OH-58 and OH-6 reconnaissance helicopters. The LHX is intended to be capable of performing multiple missions against advanced enemy air defenses of the 1990s. As an armed reconnaissance helicopter, it will conduct battlefield reconnaissance for ground commanders, during which it will fly over enemy territory and report on enemy positions. As a light attack helicopter equipped with the Hellfire antitank missile, it will be used to find and attack enemy tanks and armored vehicles as they advance toward U.S. ground forces. In addition, the Army intends to use the LHX in limited cases to conduct (1) deep attack missions behind enemy lines as part of the AirLand Battle doctrine and (2) air combat operations against enemy helicopters. The latter missions, which are not performed by current helicopters, are relatively new and will be evaluated further in the LHX's cost and operational effectiveness analysis.

Performing multiple missions, surviving against the threat, and meeting the goal of light weight require the use of several sophisticated technologies on the LHX. These include a nonmetal airframe, advanced target acquisition and night vision sensors, and very high speed integrated circuitry. Figure I.2 shows an artist's conception of proposed designs of the LHX.

Figure I.2: Artist's Conception of Proposed Designs of the LHX



Bell McDonnell Douglas



Boeing Sikorsky

In November 1988 the Army awarded cost-plus-fixed fee contracts to two contractor teams that are competitively developing the airframe and avionics during the demonstration and validation phase. One team is comprised of Bell Helicopter Textron and the McDonnell Douglas Helicopter Company, and the other is comprised of Boeing Helicopters and Sikorsky Aircraft Division of United Technologies Corporation. These contracts are to run for 23 months, after which the Army will select one team to conduct full-scale development.

The LHX T800 engine development is further along than airframe development and is following a similar strategy. In October 1988 the Army awarded a firm fixed price contract to the Light Helicopter Turbine Engine Company, a company formed by the Allison Gas Turbine Division of General Motors and the Garrett Engine Division of the Allied Signal Corporation, to complete engine full scale development and qualification.

Requirements

The general requirements for the LHX are twofold: to field a multimission helicopter that can survive against the future threat and to reduce fleet

size by replacing older helicopters with fewer of the more capable LHXs. The task of addressing these requirements while meeting the goals of light weight and low cost has proven difficult, and specific performance requirements have undergone numerous iterations as a result.

Although conceived as a small, inexpensive, single seat helicopter, the original mission requirements developed for the LHX were so demanding that they caused the Army to abandon the single-seat design. This change increased aircraft cost and weight. Thus, when OSD determined the program was not affordable in 1988, the Army reduced technical performance requirements to reduce aircraft cost and weight. During the demonstration and validation phase, the contractor teams will propose additional requirements trade-offs to reduce cost and weight further.

Even with further requirements reductions, the LHX will represent a significant increase in capability over the older helicopters it is to replace. It will offer improvements over AH-1, OH-58, and OH-6 helicopters in nearly every category, including firepower, survivability, targeting, night vision, and flight performance. However, given its significant cost, whether the LHX is the most cost-effective way to meet these requirements is unknown and will be addressed during the demonstration and validation phase. Alternatives to developing this helicopter include modifying the AH-64 Apache attack helicopter and using derivatives of commercial helicopters with LHX-type avionics and other improvements. Whether the LHX program represents the best approach depends on (1) the results of a cost and operational effectiveness analysis the Army will conduct during 1989 and 1990 and (2) the ability of the LHX to avoid cost growth and to meet performance requirements.

Schedule

Although the LHX's schedule has undergone many changes, estimates of completing development and fielding production helicopters have been relatively stable in the past 2 years. The LHX's current schedule is shown in table I.3.

Table I.3: Current LHX Program Schedule

Event	Date
Demonstration/validation decision	June 1988
Award demonstration/validation contracts	Nov 1988
Source selection	Dec 1990
Full-scale development decision	Dec 1990
First flight	Aug 1993
Low-rate production decision	Nov 1994
Complete full-scale development	Nov 1996
Full-rate production decision	Nov 1996
Initial operational capability	Nov 1996

We believe the schedule is optimistic for several reasons. First, achieving the schedule will depend on successfully integrating and demonstrating the advanced technologies and controlling aircraft weight. Second, the acquisition strategy chosen as a result of funding reductions has made the full-scale development decision susceptible to delay. Because of the funding reduction that took place in 1988, the Army deleted test and evaluation of competitive prototypes from the demonstration and validation phase, which was to have occurred during a first flight test of the prototypes in May 1991. Under the revised strategy, competition between the two airframe teams will consist of paper studies and laboratory demonstrations of selected subsystems, and the first flight test is now scheduled for August 1993 during noncompetitive full-scale development. As a result, decisionmakers may not have critical information provided by fabricating and testing prototypes—such as demonstrating technical performance and the realism of cost estimates—when needed for contractor selection and the full-scale development decision.

Risks are also evident in the latter stages of the LHX's schedule. For example, full-scale development will not be completed until November 1996, whereas low-rate production is scheduled to begin in November 1994. Such concurrency increases the risk of schedule slippage. Also, the Army plans to produce the LHX at a peak rate of 216 a year, a potentially unaffordable rate when compared with the peak rates reached by helicopters still in production--the AH-64 (up to 144 per year) and the UH-60 (up to 96 per year). Currently, the 216-helicopter production rate is too costly given projected funding levels. After the Army prepared its cost and schedule estimates, OSD projected that future funds would allow a peak production rate of only 157 LHXs a year.

The Army is looking for ways to devote more funds to the LHX, but if more funds cannot be found, then the production rate will be lower and the production schedule will slip. Also, the schedule will likely slip if estimated costs increase without a matching increase in funding or if funding levels are reduced.

Performance

Although performance requirements have been reduced, the LHX remains a sophisticated aircraft—its mission equipment and avionics are comparable to the Air Force's Advanced Tactical Fighter—and faces considerable technical risks. The area of greatest technical risk is in mission equipment (avionics and sensors), which is the most critical aspect of the program. The LHX's mission equipment will require the development of several advanced technologies such as more advanced threat sensors than those of the Army's current attack helicopters and high-speed, high-capacity integrated circuits to process and integrate flight, threat, and other critical data. The LHX will also include advanced technology in the form of an all-composite (nonmetal) airframe designed to be difficult to detect by threat sensors.

Technical risks accrue not only to the individual technologies being pursued but also to their successful integration. The Army has conducted a number of technology risk reduction efforts and plans additional work in higher risk areas during the demonstration and validation phase. However, the bulk of mission equipment testing is yet to come, and testing of a fully integrated system is scheduled during full-scale development.

Another technical challenge facing the LHX is meeting performance requirements while keeping aircraft weight low. Less weight translates into greater aircraft agility and maneuverability as well as lower procurement and operation and support costs. Although an empty weight goal of 7,500 pounds was originally established, weight estimates reached as high as 9,800 pounds in 1987, reflecting attempts to meet performance requirements. Since then the Army has made a number of performance trade-offs to lower weight, and the LHX is now about 350 to 400 pounds above the goal. Additional trade-offs will be needed not only to meet the goal but also to allow for a 5 to 10 percent weight increase that historically occurs during aircraft development programs. In addition, future weight growth from a planned improvement—amounting to several hundred pounds—is currently excluded from the weight goal.

Cost

As of March 1989, the Army estimated acquisition costs for 2,096 LHXs at $40.5 billion (escalated dollars): $3.9 billion for research and development and $36.6 billion for procurement. The total program acquisition cost estimate is $27.5 billion in fiscal year 1989 constant dollars. The June 1988 and March 1989 estimates reflect program reductions in the form of design trade-offs and lower quantities that have occurred since the program cost estimate crested in 1987. Table I.4 illustrates the changing program cost estimates since 1987.

Table I.4: LHX Cost Estimates (Constant Fiscal Year 1989 Dollars)

Dollars in millions

Cost category	Feb. 1987	Nov. 1987	June 1988	Mar. 1989
Research and development	$4,200	$4,993	$3,463	$3,311
Procurement	45,483	53,825	27,570	24,196
Total	**$49,683**	**$58,818**	**$31,033**	**$27,507**
Unit cost	$11.0	$13.7	$14.8	$13.1
Acquisition quantities	4,509	4,301	2,102	2,102
(Development/production)	(9/4,500)	(9/4,292)	(6/2,096)	(6/2,096)

The cost increases through November 1987 occurred primarily because the Army found that requirements necessitated additional mission equipment and aircraft structure. The increase in estimated research and development costs in 1987 reflects the Army's decision to extend contractor competition through the test and evaluation of prototypes. The June 1988 estimate reflects the program reductions made during 1988 to lower cost. The major cost reductions were achieved by (1) reducing competition during development, (2) lowering production quantities from 4,292 helicopters to 2,096 by deleting a utility version of the LHX originally intended to replace UH-1 helicopters, and (3) establishing lower unit aircraft cost and weight goals. The March 1989 estimate reflects additional program changes and events that the Army believes will result in lower program costs. The lower estimate was based on reductions in (1) production cost estimates agreed to under contract with the engine manufacturer, (2) mission equipment weight due to a decrease in capabilities, and (3) other areas estimated as a percentage of total costs, including nonrecurring charges, system project management, and engineering changes. It also reflected the use of revised inflation rate computations.

Although DOD has taken difficult steps in substantially reducing the LHX program, cost increases may occur in the future. The Army has made

difficult performance and weight trade-offs to meet the new unit flyaway cost goal of $7.5 million (constant fiscal year 1988 dollars),[5] but program uncertainties still exist that may result in higher costs in the future. According to the OSD Cost Analysis Improvement Group (CAIG), uncertainties regarding the cost of avionics, software development, system integration difficulties, and weight growth are likely to increase LHX costs. Schedule delays are another potential source for cost increases. For example, if the peak production rate is reduced from 216 to 157 LHXs a year, the program schedule will lengthen and costs will increase.

Program officials acknowledge the potential for cost increases and state that the primary purpose of the current demonstration and validation phase is to conduct the necessary trade-offs to achieve and keep the cost and weight goals.

While the Army considers the LHX program a high priority, the program has had significant funding cuts, and it remains a target for future cuts because it is a large investment whose affordability is a concern to OSD. The large cuts made during 1988 changed the LHX's size, missions, performance, quantity, and acquisition strategy.

The Army believes that funding is adequate to carry out LHX research and development under the revised acquisition strategy. However, this lower cost strategy is not without some potential risks. In particular, the revised strategy reduces competition and defers the availability of key information provided by fabricating and testing prototypes until after the full-scale development decision is made.

The affordability of the LHX will remain a concern in the future. Projected procurement funds are not sufficient for planned production rates, even with no cost growth. OSD does not consider the program exempt from future funding cuts, and, in fact, LHX funding was substantially cut in initial fiscal year 1990 budget reductions proposed by the Defense Resources Board. The funding was restored based on the Army's subsequent defense of the program made to the Board.

[5] Flyaway cost includes all production costs (recurring and nonrecurring) that are incurred in the manufacture of a usable end-item. It includes the prime mission equipment (basic structure, propulsion, electronics) and the allowances for engineering changes and warranties. It does not include research and development costs, training equipment, support equipment, initial spares, technical data, and publications or contractor services.

Recent GAO Reports

Light Helicopter Program: Risks Facing the Program Raise Doubts About the Army's Acquisition Strategy (GAO/NSIAD-89-72, Dec. 23, 1988).

Weapon Systems: Status of the Army's Light Helicopter Family Program (GAO/NSIAD-87-117FS, Mar. 13, 1987).

Multiple Launch Rocket System's Terminal Guidance Warhead

The Army's Multiple Launch Rocket System (MLRS) Terminal Guidance Warhead (TGW) program is to develop a target-sensing submunition for attacking armored targets at long range. A four-country consortium—the United States, the United Kingdom, the Republic of France, and the Federal Republic of Germany—is sharing the technology and the cost to develop the program. The United States is funding 40 percent of the development. While procurement quantities are tentative, the Army estimates the U.S. portion of the development and procurement costs at $7.3 billion (escalated dollars).

In 1982 the four countries determined that the MLRS TGW was the best technical approach to gain battlefield leverage against a superior armored threat. In February 1989 DOD approved the system's transition to the system demonstration substage[1] contingent upon the Army addressing several concerns. The full-scale development decision is scheduled for 1992, and production is scheduled to begin in early 1995—more than 5 years later than originally planned.

On the basis of favorable emerging test data and the assumption that the remaining tests will provide similar results, the Army believes that performance risk is medium or less. But it has not begun critical system tests nor has it implemented a program to resolve potential shortfalls in satisfying requirements unique to the United States. In addition, its most recent cost estimate shows a decrease because of a reduction in planned TGW-equipped rockets; however, the cost estimate could change because of ongoing reevaluations of rocket requirements.

Background

The MLRS TGW is to be an all-weather weapon that will use the basic MLRS launcher to fire from remote locations. The system will use the standard MLRS rocket motor to propel a warhead structure to the target area where the warhead will dispense three terminally guided submunitions. Each submunition will contain a seeker that is to activate the submunition's independent functions of guiding and controlling the warhead and searching for and engaging the target. The submunitions will rely upon miniaturized, sophisticated, and complex components to perform these functions. If successfully developed, the new seeker technology will provide significant advantages over other technologies. Figure I.3 shows a representation of the MLRS TGW and figure I.4 shows the components of the submunition.

[1]System demonstration is the final substage of the demonstration/validation phase of the acquisition process.

Figure I.3: MLRS TGW System

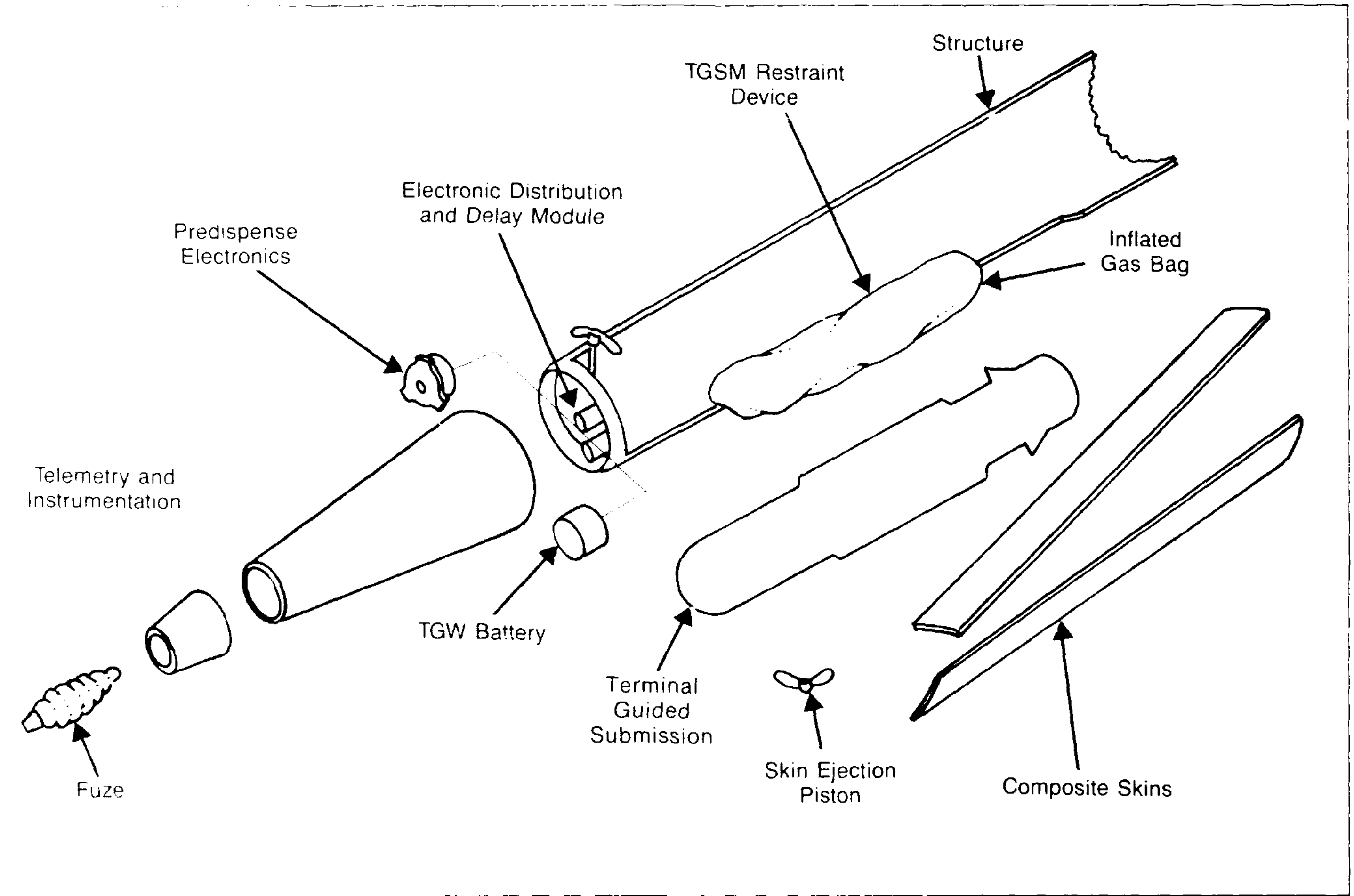
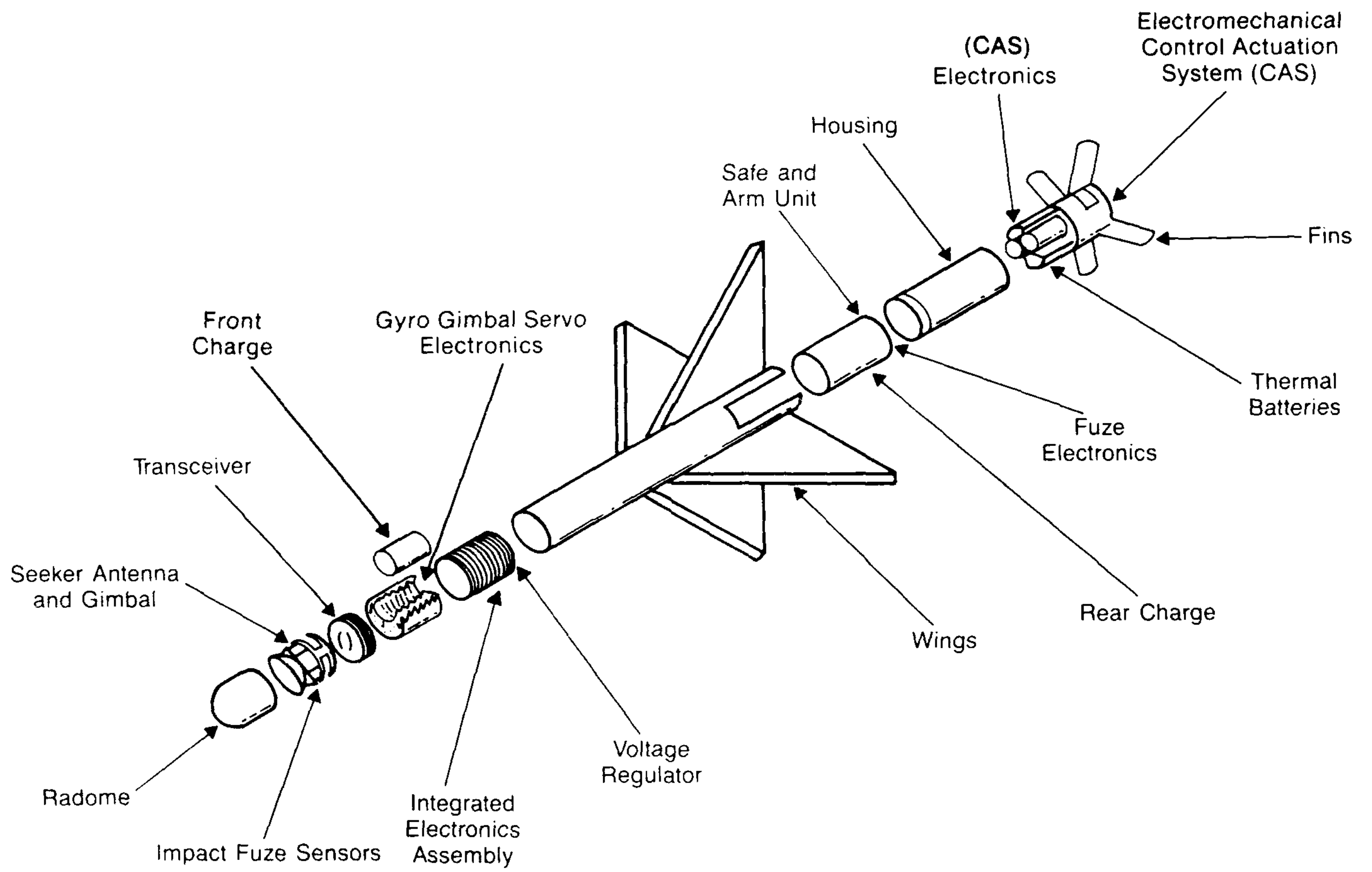


Figure I.4: MLRS Terminally Guided Submunition



TGW is intended to improve accuracy and lethality. It will supplement, rather than replace, existing equipment and munitions. The Army plans to use it in conjunction with other munitions against armored targets behind enemy lines.

Since the MLRS TGW program required developing technology that was not yet proven, the Army originally planned a three-phase developmental approach: a two-phase validation program—component demonstration and system demonstration—followed by a maturation phase that included full-scale development and low-rate production. However, because of funding constraints, the Army now plans to separate full-scale development and production phases.

In November 1984 the Army awarded a cost-plus-incentive-fee component demonstration contract to MDTT, Inc., the joint venture of Martin Marietta Corporation (United States), Thompson (France), THORN EMI Electronics, LTD (United Kingdom), and DIEHL GmbH & Co. (Germany). The contract includes system demonstration validation and full-scale development options. The Army expected to exercise the system demonstration option as scheduled in July 1989 but said that a later award was possible. Major government reviews are scheduled after each acquisition phase to determine if the program should continue.

Requirements

In 1979 and 1982 the four countries determined that an MLRS autonomous, antiarmor terminal guidance warhead capability was the best technical approach for (1) improving munitions accuracy and lethality deficiencies and (2) providing an effective field artillery to conduct deep strikes behind enemy lines. In August 1984 and again in April 1987, the Army's Cost and Operational Effectiveness Analyses concluded that the MLRS TGW and the Sense and Destroy Armor Munitions were the preferred munitions mix to satisfy this need. The Army expected to approve its required draft operational capability document defining system requirements by September 1989.

Depending upon the results of ongoing test and evaluation, the weapon system may not satisfy certain requirements unique to the United States. The MLRS project office is considering a separate program to address this potential shortfall, but as of mid-June 1989, it had not implemented the program. The details of the U.S. requirements are classified.

Schedule

In February 1989 DOD approved the MLRS TGW entering the system demonstration substage contingent upon the Army addressing specific concerns. These concerns were

- a cost and operational effectiveness analysis that compares the MLRS TGW to alternative approaches for defeating Soviet armor,
- a detailed definition of the actions to be taken during the system demonstration substage to improve submunition producibility, and
- a test and evaluation master plan that defines the specific quantitative test goals for entry into full-scale development, including a plan to demonstrate seeker maturity.

As approved, the production schedule has slipped more than 5 years, including a more than 3-year delay in the validation phase. However, the project office now believes system demonstration schedule risk for the current program is moderate or less.

According to the MLRS project manager, the actions necessary to satisfy DOD's concerns will not affect the system demonstration substage schedule. Table I.5 compares the Army's original schedule, an early 1988 schedule, and a June 1989 milestone schedule—the Army's most current schedule.

Table I.5: MLRS TGW Program Schedule Changes

Event	Dec. 1985	Feb. 1988	June 1989
Army system demonstration substage decision	Feb. 1987	Nov. 1988	Jan. 1989
DOD system demonstration substage decision	Mar. 1987	Jan. 1989	Feb. 1989
DOD system demonstration substage review	[a]	[a]	Sept. 1989
Army/DOD full-scale development decision	Mar. 1989-Apr. 1989	Nov. 1991-Jan. 1992	July 1992-Aug. 1992
Initial production decision	Apr. 1989	Jan. 1992	Jan. 1995
Initial production contract award	June 1989	Feb. 1992	Feb. 1995
Production qualification testing	Dec. 1990	Aug. 1993	Feb. 1997
Full-rate production decision	Aug. 1991	May 1994	Sept. 1997
Full-rate production contract award	Sept. 1991	June 1994	Oct. 1997
First unit equipped		Classified	
Initial operational capability		Classified	

[a]DOD established the system demonstration review milestone after February 1988

Project officials responsible for technical and program management attribute the more than 3-year delay in beginning full-scale development to contractor start-up difficulties, contractor problems in developing and manufacturing submunition components, a warhead redesign required to meet an upgraded armored threat, and a delay in awarding the system demonstration substage contract. In addition, the MLRS Chief of Program Management stated that the June 1989 schedule would delay production by 3 years because the Army's budget would not permit initial production in 1992. This schedule revision also eliminates production during the full-scale development phase, providing additional time for testing before committing production funds. Because of this additional test time, the Chief believes the overall schedule risk is moderate or less.

Performance

The U.S. Army Materiel Systems Analysis Activity concluded in its November 1988 assessment of TGW system demonstration that all areas of risk—including the critical area of seeker performance--are medium or less. The assessment was based on favorable emerging test data and the assumption that remaining tests would provide similar results. However, because system demonstration testing has not begun, a current assessment of TGW's readiness for full-scale development is not feasible. According to the Chief of the MLRS Technical Management Division, the Army will complete the most critical of these tests, including 15 submunition drop tests and 10 tactical flight tests, by September 1992. He said the seeker's ability to track and hit the target is the most critical function to be evaluated.

Cost

The Army estimates acquisition cost for the U.S. portion of the MLRS TGW to be $7.3 billion (escalated dollars). This cost is less than the September 1987 estimate because the Army reduced the number of TGW-equipped rockets to be procured by 50 percent. However, this could change based on an ongoing Army review of the number of missiles needed. In addition, according to a member of DOD's CAIG, the current cost estimate has substantial risk. Table I.6 shows the cost estimates for September 1987 and January 1989.

Table I.2: MLRS TGW Cost Estimate
(Constant Fiscal Year 1989 Dollars)

Dollars in millions

Item	Sept. 1987 estimate	Jan. 1989[a] estimate	Change
Development	$419.4	$461.7	$42.3
Procurement	8,388.7	4,797.7	−3,591.0
Total	**$8,808.1**	**$5,259.4**	**$−3,548.7**

[a]The project manager believes this estimate is reasonable, and the Army's Cost Economic Analysis Center validated it.

According to a project office cost analyst, the estimated development cost increased because of unfavorable foreign exchange rate adjustments, a revision to the program schedule, and development funding requirements unique to the U.S. program. This official attributed the $3,591 million decrease in the procurement estimate to an error in the earlier estimate amounting to 50 percent of the planned procurement quantity. However, the Army is reviewing the quantity of TGW-equipped rockets required for use in combination with other deep strike systems. According to the study director, this review—the Deep Strike Cost and Operational Effectiveness Analysis—could alter the number of

TGW-equipped rockets to be procured. The Army expects to complete the review in early 1992 before TGW's full-scale development decision.

In addition, a 1987 evaluation of the TGW program by CAIG indicated that the TGW program, at that time, had serious problems and a low probability of success. CAIG believed that cost and schedule estimates were too optimistic, and it expressed reservations about the system achieving its technical objectives because the technology was too risky. In February 1989 CAIG performed a new analysis that only considered cost, not technology risks. According to the CAIG Chairman, the group judged that the Army's January 1989 production cost estimate may be understated by as much as 50 percent. The Chairman stated that their assessment questioned the estimate in the areas of (1) estimating methodology and assumptions, (2) exchange rate projections during the production phase, and (3) seeker production cost. CAIG declined to discuss the specific amounts involved, but on the basis of percentages provided, we calculated that the understatement could amount to $2.4 billion (constant dollars).

Program Priority and Affordability

The project manager and the Office of the Secretary of the Army (Research, Development and Acquisition) action officer both stated that the TGW program has high priority, and a DOD staff specialist for land warfare stated its status as an international effort may give the program special consideration. However, he stated that the entire full-scale development and procurement phases are unfunded because the Deputy Secretary of Defense decided that funding should not be committed until completion of the system demonstration substage. According to a project office cost analyst, the shortfall in projected development and procurement funding amounts to (1) $183 million (escalated dollars) in research and development funding for fiscal years 1992 through 1994 and (2) $6,810.3 million (escalated dollars) in procurement funding for fiscal years 1995 through program completion.

Recent GAO Report

DOD Acquisition Programs: Status of Selected Systems (GAO/NSIAD-88-160, June 1988).

Line-Of-Sight Forward Heavy Weapon System

The line-of-sight forward heavy (LOS-F-H) air defense system will be a tracked vehicle that uses missiles and a gun to attack enemy aircraft. The Army selected a new supersonic missile system mounted on a modified Bradley vehicle chassis to satisfy its LOS-F-H air defense requirement. The system is called the Air Defense Antitank System (ADATS) by the contractor, Martin Marietta, and is shown in figure I.5. It is one of three new weapon systems in the Army's new Forward Area Air Defense System (FAADS), which is to provide new weapons for strengthening air defense in forward combat zones. The Army plans to purchase 562 LOS-F-H weapon systems and estimates the total program acquisition cost at $6,802.0 million (escalated dollars). This cost may increase after the Army completes renegotiating its production contract with Martin Marietta. Program officials indicate that as the weapon system enters the full-rate production phase, costs also may rise due to system refinement.

The first systems produced, about 148 units, will have a missile system only, but a gun may be included on later units. Four preproduction weapons were ordered for the testing program and all were delivered. In August 1989 the Army ordered four more units to be used in testing.

Figure I.5: Initial LOS-F-H [illegible] Fire Unit

Last year we reported the LOS-F-H system was scheduled to enter full-rate production no later than December 1989. A June 1989 revision to the program schedule now shows a low-rate initial production decision to be made in June 1990, the full-rate production decision to be made in March 1991, and initial fielding to be in May 1993. The Army delayed the program for several reasons—to allow time for training, to complete additional testing required by legislation, and to accommodate funding cuts. The Defense Acquisition Board, which reviewed the program in 1988, also asked the Army for additional testing and analyses of the LOS-F-H performance. In addition, tests to determine LOS-F-H operational

effectiveness and suitability and the degree of improvement over existing systems were delayed to April 1990.

Background

The LOS-F-H, which will be located in forward battle areas, will be directed by radar, optical sensors, and laser guidance to detect, identify, and defeat attack helicopters and low-flying, fixed-wing aircraft. Two other new FAADS weapons—the Pedestal Mounted Stinger and the Fiber Optic Guided Missile (FOG-M) systems—also will operate in the forward areas and provide protection to combat forces. Together these weapon systems comprise three of the five elements of FAADS.

Requirements

The Army established the LOS-F-H weapon requirement based on the expected air threat and a study of Army air defense needs for combat forces, as validated by the Defense Intelligence Agency and Army Intelligence. A required operational capability document, dated March 1987, states the need and requirements for LOS-F-H. According to this document, the system is to have a missile and a gun weapon system mounted on an armored-tracked vehicle. It is intended to destroy enemy helicopters and fixed-wing aircraft in the forward battle area, day or night, in adverse weather conditions, and under conditions where electronic and physical countermeasures are present. Also, the system must be able to operate autonomously or with a planned command and control network. Although the required operational capability document calls for a gun, the first 148 units will be purchased without one. According to Army officials at the program office, a 25 mm Bushmaster gun may be included on subsequent units, but a final decision on this has not been made.

To accelerate system deployment, the Army selected its LOS-F-H weapon from systems in or ready for production. The weapon also had to be able to evolve to counter a possible change in threat. The Army used competitive tests and selected Martin Marietta's ADATS for the requirement.

In February 1986 the Army began analyzing FAADS' cost and operational effectiveness. The study focused on performance capabilities because reliable cost data were not available to compare alternative systems, and its objective was to determine the most operationally effective mix of forward area air defense weapons. The study, which used simulations representing a variety of operational scenarios, showed that the effectiveness of the LOS-F-H weapon was mixed. During one simulated scenario, which assumed an aerial sensor capability, FOG-M identified and

destroyed most of the enemy helicopters before the LOS-F-H weapon had an opportunity to engage them. In other scenarios where an aerial sensor was not available, the Army concluded that the LOS-F-H would provide better protection of ground forces maneuvering in close operations. Under these conditions, the study indicated that the LOS-F-H weapon destroyed more helicopters and protected friendly forces from enemy air attack better than any other system.

The Army provided its analysis to OSD in August 1988, and in September 1988 OSD asked the Army to conduct more tests and to make additional weapons performance analyses. It also requested the Army to make a cost analysis that compared FAADS' life-cycle costs to the costs of the existing air defense systems. In December 1988 the Army provided OSD an assessment of the (1) potential countermeasures to FOG-M, (2) effectiveness of the current short-range air defense weapons, and (3) a cost analysis of FAADS. The life-cycle cost estimate for FAADS was $27.8 billion, excluding the combined arms estimate, which was $15.8 billion more than those estimates for existing short-range baseline systems—the Vulcan, the manportable Stinger, and the Forward Area Alerting Radar. In terms of performance, however, in at least one scenario where a direct comparison could be made, FAADS weapons were 6 to 20 times more effective in defeating enemy aircraft than existing systems. The Army plans to provide two additional studies, a weapons mix analysis and a FAADS sensitivity analysis, to OSD in August and October 1989, respectively.

Schedule

The National Defense Authorization Act, Fiscal Year 1989 (P.L. 100-456) provides that the Secretary of the Army may obligate $85 million in fiscal year 1989 for LOS-F-H procurement only after DOD's Director of Operational Test and Evaluation certifies to both the House and Senate Committees on Armed Services that he has approved the Army's planned qualification and operational testing for LOS-F-H. The Director approved the Army's plans on February 14, 1989, and the operational test is now scheduled to begin on April 9, 1990, and last about 7 weeks. The act also provides that the Secretary of the Army may not obligate procurement funds for LOS-F-H for any fiscal year after 1989 until (1) the operational test is completed, (2) the Secretary of Defense certifies to these Committees that LOS-F-H meets or exceeds the Army's operational performance criteria, and (3) the Director of Operational Test and Evaluation and GAO provide evaluations of system performance to the Committees.

Table I.7: Comparison of LOS-F-H Program Schedules

Event	June 1988 schedule	June 1989 schedule
Competitive evaluation	July 1987	[a]
First preproduction unit delivered	Feb 1989	[a]
Begin operational testing	July 1989	Apr 1990
Low-rate initial production decision	[b]	June 1990
Full-rate production decision	Dec. 1989	Mar 1991
Initial fielding	Nov 1991	May 1993

[a] Completed

[b] The low-rate initial production decision was added in June 1989

The Army is testing LOS-F-H prior to its planned operational test and the scheduled production decisions. The tests are designed to examine, test, and validate tactics, doctrine, and organizational concepts. Other testing will involve live-fire testing, simulated missile firings, target acquisition, and target tracking. A refurbished LOS-F-H, used in the competitive testing, was used for testing purposes from April 1988 through December 1988, and the four preproduction units will be used for additional testing through March 1990.

Operational testing needed to confirm the operational suitability and effectiveness of LOS-F-H prior to a production decision will use the four preproduction systems. The full-rate production decision date has slipped 15 months since last year's estimate and is now scheduled for March 1991.

During the past year, the initial fielding date for the first LOS-F-H systems has slipped from November 1991 to May 1993. According to the Army, the delay is due largely to budget cuts, but the requirement to test LOS-F-H thoroughly before the planned full-rate production decision remained constant.

During fiscal year 1989, the Army planned to award Martin Marietta three fixed-price contracts, totaling about $142.0 million, for LOS-F-H procurement. The Army awarded a contract for $33.5 million for long-lead items in October 1988 and a contract for four systems in August 1989. These units will be used for production qualification testing and operational testing. The Army planned to award the third contract for about $23.5 million for long-lead items in late fiscal year 1989.

The Army and OSD consider the program schedule to involve low risk because full-rate production is dependent on the weapon's successful completion of the technical and operational tests.

Performance

After ADATS was selected for the LOS-F-H requirement, the Army conducted a series of preoperational tests on the weapon. The results of this testing are classified. The operational test rescheduled to begin in April 1990 will provide information critical to determining whether LOS-F-H represents an improvement over the existing forward area air defense weapons significant enough to enter full-rate production.

Operational testing will be based on the threat projected for 1993 when the LOS-F-H is initially fielded. The Army recognizes that this threat, particularly the number of helicopters capable of hovering, identifying targets, and firing missiles from great distances, will continue to increase after 1993. The operational test schedule includes testing LOS-F-H against about equal numbers of fixed-wing aircraft, forward-moving and hovering helicopters, and several mixed threats.

The Army does not plan to compare LOS-F-H to the existing forward area air defense weapons in a live side-by-side test. According to Army and DOD operational test and evaluation officials, it is not necessary to have a side-by-side test of the systems because sufficient test results have been acquired for existing weapons. Therefore, they plan to use computer simulations to compare LOS-F-H test results with performance data on the existing forward area air defense weapons. This approach, however, may not provide a valid comparison in selected scenarios because the performance data for the existing weapons might have been obtained under quite different test conditions.

Cost

The estimated program costs for the LOS-F-H requirement have increased since the initial December 1986 estimate, largely due to changes in initial system definition. Estimates made in 1986, 1987, and 1988 were each based on different weapon/vehicle concepts. The current estimate of $6,802.2 million is based on the estimated cost for Martin Marietta's ADATS system and excludes about $441 million for product improvement items, including the gun. A comparison of the Army's cost estimates for the LOS-F-H is shown in table I.8.

Table I.8: Cost Estimates for the LOS-F-H
(Escalated Dollars)

Dollars in millions

Item	Dec. 1987 estimate	Dec. 1988[a] estimate	Change from 1987-88
Research and development	$272.9	$265.9	$-7.0
Procurement	5,982.8	6,536.1	55.3
Total	**$6,255.7**	**$6,802.0**	**$48.3**
Acquisition unit cost (based on 562 units)[b]	$11.1	$12.1	$1.0

[a]Cost estimates included in the Army's December 1988 baseline cost estimate for LOS-F-H

[b]Acquisition unit cost includes fire unit, 16 missiles, and all firing devices that go with the unit

OSD plans to verify the Army's estimates before the March 1991 full-rate production decision. Program officials indicate that costs may increase when the system becomes better defined and enters the full-rate production phase.

Recent GAO Reports

DOD Acquisition Programs: Status of Selected Systems (GAO/NSIAD-88-160, June 30, 1988).

Weapon Systems: Acquisition of the Army's Line-of-Sight Forward Area Air Defense System (GAO/NSIAD-88-198, June 30, 1988).

DOD Acquisition Programs: Status of Selected Systems (GAO/NSIAD-87-128, Apr. 2, 1987).

Navy Programs

Five-Inch Rolling Airframe Missile System

The five-inch Rolling Airframe Missile (RAM) and its launching system are designed to provide defense against antiship cruise missiles that penetrate the outer layer and area defense systems.[1] The system is intended to replace short-range Basic Point Defense Missile Systems on 14 amphibious ships and to complement the North Atlantic Treaty Organization (NATO) Sea Sparrow and the Phalanx close-in weapon systems on various Navy vessels, such as frigates and destroyers. RAM is concurrently in full-scale engineering development and low-rate initial production. A full-rate production decision is planned for August 1990. RAM is a NATO cooperative program, with the Federal Republic of Germany sharing the costs and providing a second source for missile acquisition. Total U.S. development and procurement costs are estimated at $1.6 billion.

In the early 1980s RAM experienced numerous cost, schedule, and performance problems that threatened the program's continuation. The Navy believes these problems have been resolved, and during initial operational tests, held from December 1986 through February 1987, 11 of 13 missiles fired successfully hit the target. On the basis of these test results, the program office considers program risk to be low and believes critical items needed to complete testing and begin full-rate production will be available as required. The Navy anticipates only minor delays in its testing schedule, but, in response to budget constraints, it has stretched out completion of the current acquisition program by 5 years.

Background

RAM, shown in figure II.1, is described as a lightweight, quick-reaction self-defense system that will increase the survivability of the more vulnerable ships and provide high fire power complementary defense for ships with other self-defense weapons. System components (see fig. II.2) are the missile, launching canister, weapons control system, and guided missile launching system.

[1] The Navy uses a "layered" defense that is divided into three major zones. In the outer zone, carrier-based aircraft are the main intercepts. Area defense is provided in the middle zone predominately by ship-launched missiles. In the inner zone, short-range "point defense" systems, such as rapid-fire guns and antiship missiles, are the weapons of last resort.

Figure II.1: The RAM

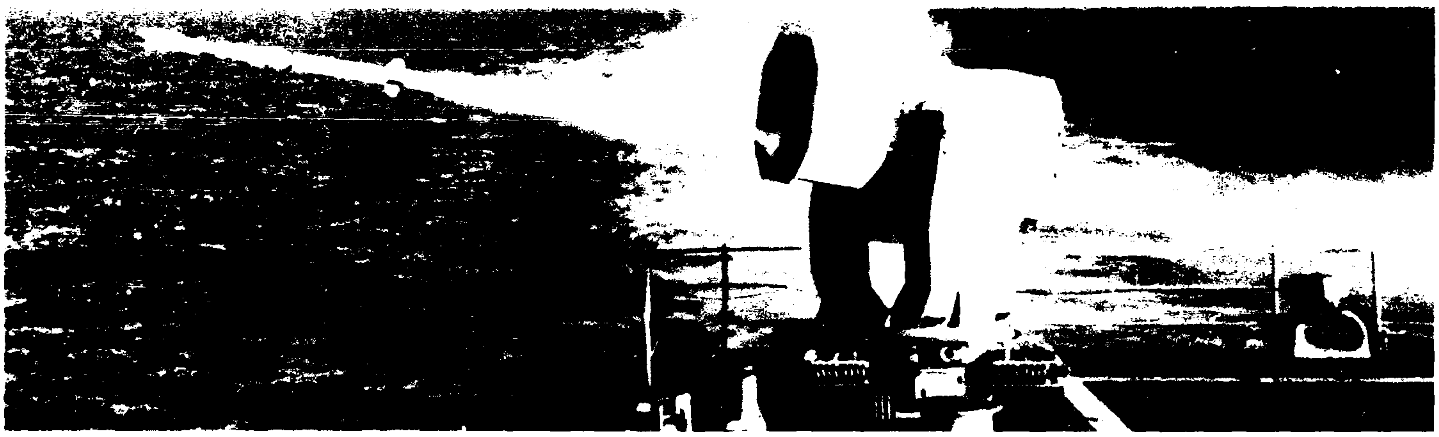
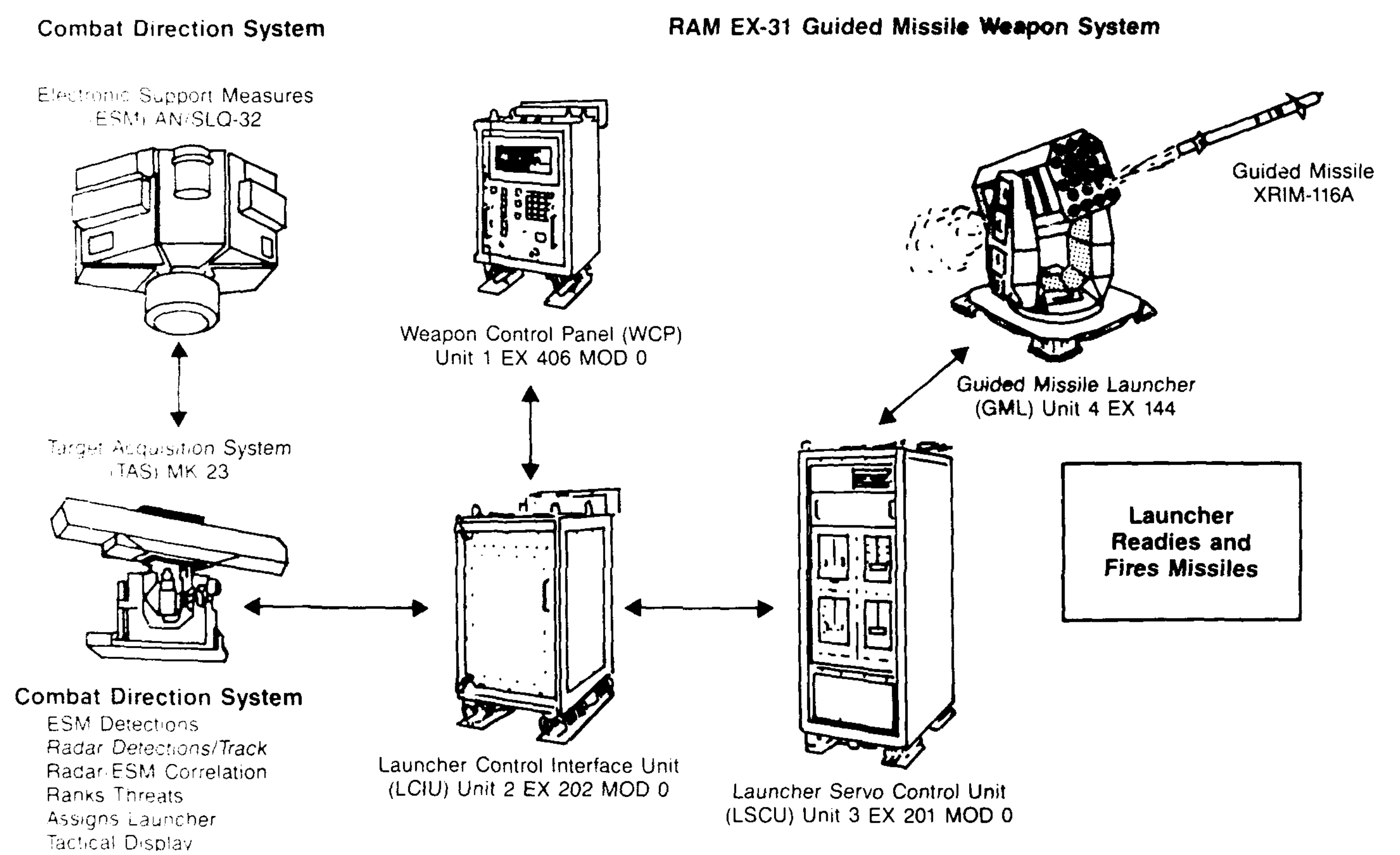


Figure II.2: The RAM Combat System



RAM is propelled by a modified Sidewinder missile rocket motor, guided by a passive dual-mode radio frequency/infrared seeker, and carries a Sidewinder warhead. The canister provides environmental protection, interfaces with the launching system, and serves as the launch tube. The launching system consists of a RAM-unique, stand-alone 21-cell launcher[2] and control cabinets. Operationally, target detection and designation is provided by the ship's MK-23 Target Acquisition System radar and the AN/SLQ-32 electronic support measures sensor in combination with a

[2] Due to anticipated cost and technical difficulties, the Navy decided not to install RAM into NATO Sea Sparrow launching systems, as originally planned. Instead, it is exploring the cost and feasibility of using RAM in its stand-alone configuration on ships equipped with NATO Sea Sparrow systems. In addition, the Navy is studying the cost and feasibility of modifying the MK-13 standard missile launcher for RAM on FFG-7 frigates, a class of ships where weight and space limitations may preclude installation of the RAM launcher.

unique threat evaluation and weapons assignment software program in the MK-23 system computer.

RAM is intended to defend against certain incoming antiship missiles equipped with active radar guidance systems that penetrate the outer layer and area defense systems. It is not designed to counter the more current antiship missiles equipped with nonradiating (i.e., passive) guidance systems, nor is it designed to counter very low flying sea skimmer-type missiles. RAM is planned as a fire-and-forget system—once launched it will not require shipboard fire control illuminators to guide the missile to the target. Improvements over other point defense systems are RAM's fully automatic, passive dual mode seeker that requires no post launch guidance support, and its increased speed and maneuverability. Future development to respond to the emerging antiship missile threat includes plans for a guidance system to engage nonradiating targets and a low altitude fuze to counter very low flying missiles.

RAM is a NATO cooperative program with the Federal Republic of Germany and the United States as the active participants. Within the terms of the 1976 advanced development and the 1979 full-scale engineering development memorandums of understanding, West Germany has shared the work effort and the costs of developing the system. General Dynamics has been the prime contractor, and West German companies have been subcontractors. In addition, these two countries signed a production memorandum of understanding on August 3, 1987, requiring (1) dual source production of the guidance and control sections, tail assembly, and canister and associated hardware and (2) coproduction of the guided-missile launching system. During full production, the U.S. prime contractor and the West German second source contractor will compete for annual missile requirements and are to act as coproducers of launching systems. Government furnished equipment include the rocket motor with the arming and firing device, the ordnance package target detector and contact fuze, and the warhead and safe and arm device.

Currently, the Navy is planning to install the MK-23 target acquisition system and two RAM systems on each of 14 amphibious ships (in place of short-range Basic Point Defense Surface Missile Systems). According to the fiscal year 1990 budget documents, RAMs are planned for use on FFG-7 class frigates; however, this ship class has space and weight limitations that may preclude installation of the RAM launcher. The Navy is also considering installing them on DD-963 class destroyers, aircraft carriers, and combat support ships.

Requirement

In November 1973 the Chief of Naval Operations published a "Statement of General System Requirements" establishing a need to develop a new self-defense system. In May 1975 the Navy issued an operational requirement formalizing the operational need for a system that would provide an improved capability to engage incoming active antiship cruise missiles. The principal mission of RAM is to increase the survivability of undefended ships—those not equipped with either the NATO Sea Sparrow or the Phalanx close-in weapon systems—and provide a complementary self-defense system on high value ships to increase fire power during saturation[3] attacks.

Initially, RAM was conceived as a small sized, low cost missile with maximum use of existing in-service components and new components, where required, based on known technology. RAM was to rely upon existing shipboard sensors to satisfy combat system requirements. In addition, the Navy needed a system with growth potential to meet the emerging threat from passive cruise missiles.

Schedule

Full-scale engineering development, originally envisioned to last about 56 months, is now scheduled to take 134 months. By September 1986, the Navy had extended the schedule more than 6 years due to an underestimate of system complexity, missile reliability failures during development tests, the time required to make engineering changes, subsequent loss of congressional support for the program, and funding reductions. Also, according to the program manager, the RAM program was underfunded in the early years, which contributed to program stretchouts.

After testing was suspended due to a series of flight failures, the fiscal year 1986 procurement funding request for testing and tooling equipment and low-rate initial production was not approved by the Congress. During the fiscal year 1987 budget hearings, the Senate and House Committees on Armed Services recommended terminating the program. However, due to the extensive West German participation, the Navy restructured the program in accordance with congressional direction in the National Defense Authorization Act for Fiscal Year 1987. The act set development and procurement cost ceilings and required DOD to certify that RAM performance would meet original development specifications and to approve a revised test and evaluation master plan. Table II.1 compares the September 1986 schedule shown in the revised plan

[3]An overwhelming concentration of military forces or fire power.

(which was approved March 6, 1987) with the current schedule as of April 1, 1989.

Table II.1: RAM Program Schedule Changes

Event	Sept. 1986	Apr. 1989
Start low-rate production	Feb 1988	May 1989
Pre-technical evaluation tests	Apr 1989	Sept 1989
Technical evaluation tests	Aug 1989	Jan 1990
Operational evaluation tests	Dec 1989	May 1990
Full-rate production decision	May 1990	Aug 1990
Follow-on development tests (validate target acquisition system radar with upgraded computer and RAM-unique evaluation and weapons assignment software)	Dec 1990	Feb 1991[a]
Follow-on operational tests	Mar 1991	Nov 1991[a]
Follow-on development tests (validate RAM at self-defense test site)	(Event unscheduled)	Mar. 1993
Completion of current program	FY 1992[b]	FY 1997[c]

Note Test dates represent completion of event

[a]Additional follow-on tests are scheduled for 1991 through 1994

[b]Program included 4 900 missiles and 30 launch systems

[c]Program includes 5 941 missiles and 85 launch systems

Since the program was restructured in September 1986, the Navy has made additional changes in the testing schedule due to delays in arrival and assembly of improved preproduction missiles and stand- alone launchers. (Further details of testing are classified.) The RAM program manager believes critical items needed to complete testing and begin full production will be available as required. We believe the current schedule is very tight and unexpected problems could extend the start of full-rate production beyond fiscal year 1990.

To reduce costs and to meet congressionally mandated unit cost restrictions, the Navy combined fiscal years 1988 and 1989 funding authority for low-rate production of 500 missiles and 6 launching systems and delayed the award of limited production contracts. On June 6, 1989, the Navy awarded an interim contract to General Dynamics, obligating \$14.9 million for missile production, and it planned to complete negotiation on this contract by mid-August 1989. A separate contract for launching systems was still pending as of June 15, 1989. Also, in response to anticipated budgetary constraints during the 1990s, the Navy has stretched out full-rate production. As of June 1989, the current program (5,941 missiles and 85 launching systems) is scheduled to

be completed in fiscal year 1997; the previous program as of September 1986 (4,900 missiles and 30 launching systems) was to have been completed in fiscal year 1992.

Performance

During initial developmental testing and evaluation in the early 1980s, RAM experienced test failures. Test results indicated a need to reevaluate the engineering design to ensure that the missile was functionally workable and to assess reliability and workmanship. Thus, the Navy suspended flight testing from February 1985 to July 1986 to conduct the evaluation, validate the engineering design, and correct numerous missile reliability problems.

The first operational test and evaluation report, dated July 1987, concluded that RAM had the potential to be operationally effective and operationally suitable and recommended approval for limited fleet introduction. Initial operational tests[4] held from December 1986 through February 1987 resulted in 11 successful missile engagements of 13 firing events; that is, 11 missiles hit the target. Six of the successful firings, made from land-based test sites using nonproduction representative launching systems, were considered missile only tests. The other seven firings occurred during system level testing of the complete RAM combat system, consisting of the missile, the launching system, the threat evaluation and weapons assignment software program, the AN/SLQ-32 electronic support measures sensor, and MK-23 Target Acquisition System radars. Five of the seven system level firing tests hit the target (one of one conducted over land and four of six on board a test ship). However, the tests had limitations that hampered assessment of RAM's performance. The following are some of the limitations.

- Tests against supersonic targets were limited to missile only tests (the nature of which do not demonstrate system capabilities against the threat).
- Certain tests required to complete evaluation of operational effectiveness (which are classified) were not performed.
- Target[5] and test facility limitations impeded testing at certain operational performance levels.

[4] Tests were combined with development tests and governed by a joint test plan

[5] Targets were the subsonic BQM-34S and supersonic MQM-8G (VANDAL) drones, which do not fully simulate the threat

According to the program manager, many limitations will be addressed in the upcoming operational tests. However, certain limitations will continue to hamper assessments of RAM's performance prior to key milestone decisions. For example, tests of the combat system configured with an upgraded computer and the unique target evaluation and weapons assignment software are scheduled to occur after the full-scale production decision.

Cost

The RAM program has experienced significant cost growth over the life of the program. Although RAM was intended to be a low cost system, the unit cost to procure missiles has increased from a development estimate of $57,000 to $166,000 (based on Navy estimates as of April 1, 1989). Table II.2 compares September 1986 and April 1989 cost estimates.

Table II.2: U.S. RAM System Costs
(Escalated Dollars)

Dollars in millions

Item	Sept. 1986[a]	Apr. 1989
Quantities (missiles/launchers)	4,900/27	5,941/85
Development	$215.6	$232.2
Procurement		
Missiles	668.8	983.5
Launchers	124.9	411.4
Total	**$1,009.3**	**$1,627.1**

[a]Cost estimates in the revised test and evaluation master plan, which was approved March 6, 1987.

U.S. program costs exclude contributions of NATO participating governments for development and production and costs of additional manpower, operations and maintenance, and modified launching systems if RAM systems are installed on ships with weight and space limitations. Also excluded are the costs of procuring planned improvements and RAM-unique upgrades to shipboard radars and electronic support measures sensors, if required.

As a result of developmental problems and cost growth, the Congress set funding limitations on the RAM program. For example, the National Defense Authorization Act for Fiscal Year 1987 required the Secretary of Defense to certify to the House and Senate Committees on Armed Services by April 1, 1987, that the Navy's cost for RAM research, development, test, and evaluation would not exceed $219.7 million and that system performance would not be degraded from the original

development specifications contained in the Navy Decision Coordinating Paper No. SO-167-AA.

The Navy estimates U.S. developmental costs at $232.2 million. This includes $211.6 million through the full-rate production decision in fiscal year 1990 and $20.6 million for infrared-all-the-way guidance and improvements in low altitude fuse capability in fiscal years 1991 through 1994 as part of the RAM product improvement program. The estimate does not include (1) $10 million that the Navy has requested for product improvements from the DOD Cooperative Research and Development Program or (2) the cost of a proposal to modify the MK-13 standard missile launcher for RAM on ships with space and weight limitations, instead of using the NATO Sea Sparrow launcher as originally planned. The Navy believes that the amount needed for the basic design of RAM is below the congressionally mandated ceiling because the infrared-all-the-way guidance and improvements for the low altitude fuse capability were not part of the original development specifications.

Acquisition costs have increased in part because of a larger inventory objective. Implementation of this plan depends on budget constraints and other issues. Costs also increased because of the Navy's decision to stretch out missile production. On the basis of Navy data, we estimate the recurring unit flyaway cost[a] for low-rate initial production of 500 missiles to be about $139,000 (fiscal year 1986 dollars), which is below the congressionally mandated ceiling of $145,000. However, recurring unit flyaway costs on average for all missiles will likely be above the congressionally mandated unit ceiling cost of $100,000 (fiscal year 1986 dollars).

Recent GAO Reports

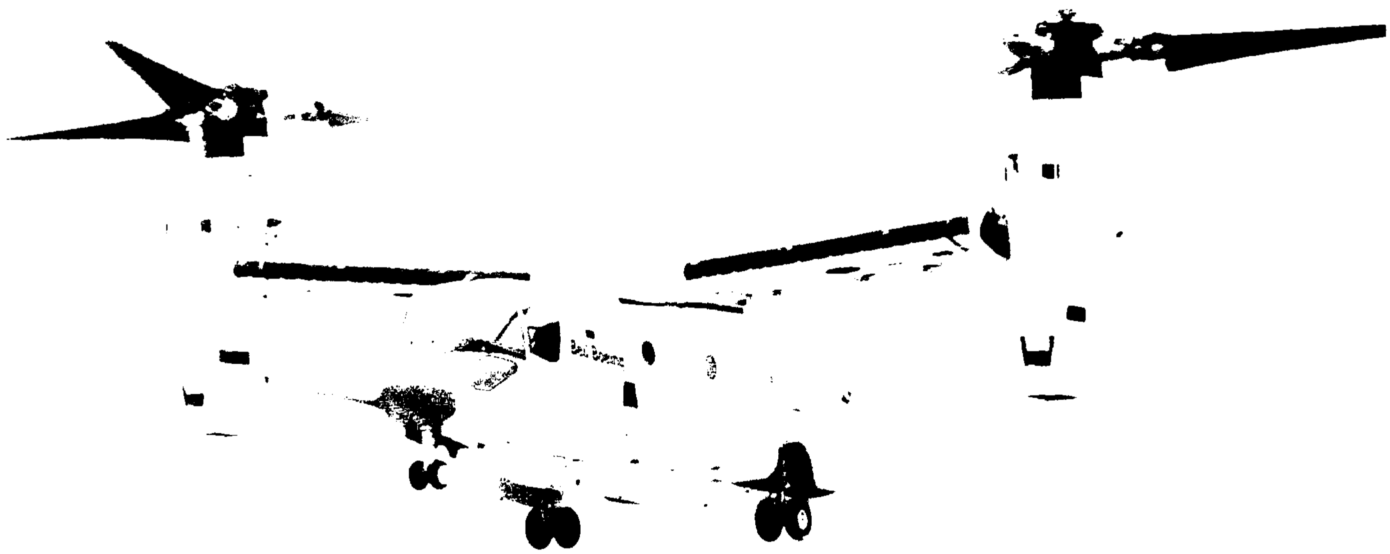
None.

[a] Recurring flyaway costs include flight hardware and production support, but exclude procurement expenditures such as canisters, tools and testing equipment, spare parts, and fleet support expenses.

V-22 Osprey Vertical Lift Aircraft

The V-22 Osprey is a tiltrotor aircraft designed to take off and land vertically like a helicopter and to fly like an airplane by tilting its wing-mounted rotors to function as propellers. The V-22 is being developed to perform various combat missions, including medium lift assault (Marine Corps), combat search and rescue (Navy), and long range special operations (Air Force). The V-22 is intended to replace the CH-46 Sea Knight and CH-53A and D Sea Stallion helicopters for the Marine Corps and the HH-3A Sea King helicopter for the Navy and to supplement existing aircraft for the Air Force. Figure II.3 shows the first full-scale development model of the V-22 in its March 19, 1989, first flight.

Figure II.3: The V-22 Osprey Vertical Lift Aircraft



Except for minor reductions, the V-22 program had been adequately funded through fiscal year 1989. However, due to budgetary constraints, the initial fiscal year 1990/1991 budget request (the Reagan budget) was at a reduced level ($1.4 billion), reflecting a change in the Navy's procurement strategy. The amended fiscal year 1990/1991

budget (the Bush budget) deleted the program due to its high cost relative to its fairly narrow mission that could be performed by helicopters. The Congress is debating whether to adopt the administration's decision to cancel the program or to continue it. Thus, we have kept this program in our report to provide information on its status and to identify issues that would be relevant if it is continued.

The V-22 program began full-scale engineering development in April 1986, with the first flight of the aircraft initially scheduled for June 1988. Technical problems that have since been resolved caused the first flight to be delayed until March 19, 1989. Nonetheless, many critical tests remain before the initial limited production decision scheduled for December 1989 can be made.

Since December 1986, the aircraft's unit cost has increased by about $6.7 million to an estimated $39.0 million (escalated dollars). This increase occurred because the Army decided not to buy the aircraft, the Air Force decided to reduce the quantity to be bought, the procurement strategy changed, and the production schedule was lengthened. As of December 1988, the V-22 was estimated to cost $25.9 billion in escalated dollars for the development and procurement of 663 aircraft. Total program cost could increase further if the Navy's recommendation to delay the low-rate initial production decision by 1 year, until December 1990, is approved.

In conjunction with the recommendation to delay production, the Navy proposed returning from a coproduction to a dual sourcing procurement strategy, starting with the fiscal year 1992 buy of 24 aircraft. Because the House and Senate Committees on Appropriations were concerned about whether the Navy's dual source strategy was cost-effective, the conference report (Report No. 100-1002) accompanying the DOD appropriations bill for fiscal year 1989 (H.R. 4781) directed the Secretary of Defense to reevaluate the Navy's V-22 dual source procurement strategy and provide a report on his findings not later than December 31, 1988. The report was not submitted in 1988, and the President's April 1989 amended fiscal year 1990 budget deleted the V-22 program and proposed to the Congress that it be canceled.

Background

According to the Navy, the V-22 combines advanced tiltrotor technology and the extensive use of composite materials to offer a unique capability to the military services. The Navy is developing the aircraft under a

fixed-price incentive contract with the contractor team of Bell Helicopter Textron and Boeing Helicopter Company. The full-scale development contract requires the team to coproduce six aircraft for flight testing and three for ground testing and also includes an option for an initial limited production buy of 12 aircraft. The engine is being developed under a firm fixed-price contract by the Allison Gas Turbine Division of General Motors.

Requirements

The program need was based on the services' requirements to replace or supplement the aging and less capable aircraft now performing the medium lift and assault missions. A service-sponsored joint technology assessment group concluded in May 1982 that the application of tiltrotor technology offered the best potential for a common multiservice aircraft. From this assessment, the services developed a set of joint operational requirements that favored a tiltrotor aircraft with a world-wide self-deployment capability, that is, an aircraft that would not depend on other transportation means for its relocation from one area to another.

Before the full-scale development decision, the Navy studied the cost-effectiveness of the V-22 in performing the Marine Corps, Navy, and Air Force missions. The studies concluded that the V-22 was the most operationally effective candidate relative to helicopter alternatives largely due to its greater speed and range, but it was also more costly. The studies showed that as mission distances increased, the V-22's operational effectiveness increased relative to helicopter alternatives. However, as mission distances decreased, its operational effectiveness was similar to the lower cost alternatives. While the studies point out that the V-22 was more costly than helicopters, they also state that this was offset by the greater V-22 operational capabilities of speed and range.

Schedule

The V-22 program has experienced a schedule slippage of 9 months in first flight since entering the full-scale development phase in April 1986, as shown in table II.3.

Table II.3: V-22 Osprey Program Schedule Changes Since Full-Scale Development Decision

Event	1986 program	Program as of Apr. 1989
Full-scale development decision	Apr 1986	Apr 1986
First flight	Jun 1988	Mar 1989
Development testing start	Jan 1989	Nov 1989
Operational testing start	Aug 1989	Nov 1989
Initial limited production	Dec 1989	Dec 1989
Limited production	Dec 1990	Dec 1990
Full production	Dec 1991	Dec 1991
Initial operating capability	May 1992	May 1992

Initially, first flight slipped 4 months, from June 1988 to October 1988, due to optimistic contractor schedules and vendor part shortages. Technical problems caused first flight to slip further, from October 1988 to March 1989, and were as follows:

- Composite grips that hold the rotor blades to the rotor hub delaminated (separated) during fatigue testing.
- Gear box test stands failed due to vendor design and quality control problems.
- Interface problems occurred when aircraft subsystems were brought together for the first time.
- Flight control software intended for first flight contained irregularities and required correction.

The contractors had sufficiently corrected the problems to enable first flight to occur in the helicopter mode on March 19, 1989; however, the contractor only developed an interim fix to the composite grip problem. Engineering and manufacturing work is continuing to develop a solution acceptable for production aircraft.

Rather than the 18 months originally scheduled for flight testing, the Navy now has only 9 months to test the aircraft before the December 1989 initial limited production decision. The original test and evaluation plan consisted of 6 months of contractor testing, followed by 12 months of Navy development and operational testing. Recognizing that there was insufficient time to conduct the original tests and still retain the production schedule, Navy program officials revised the test plan, which greatly reduced the extent of flight testing. Under the revised plan, the Navy proposed to (1) reduce the contractor testing period by 1 month, (2) decrease the number of training hours allotted to test pilots, (3) conduct combined development and operational tests consisting of 70

percent fewer flight hours, and (4) defer certain developmental/operational tests until after the low-rate initial production decision was made. According to these officials, this limited testing would still provide an adequate basis for making a low-rate initial production decision for 12 aircraft in December 1989.

In March 1989, because the Navy was still concerned about the preproduction flight test program, it recommended to DOD that the low-rate initial production decision be delayed by 1 year to enable it to retain the original test and evaluation plan. The Navy believed that without such a delay, it might not be possible to complete all the development and operational testing required to support the full-rate production decision in December 1991. Failure to complete the required tests could result in a stoppage of the assembly line between limited and full-rate production and thus increase program costs.

Performance

Performance requirements established by the Joint Services Operational Requirement for the V-22 aircraft were

- unrefueled range of 2,100 nautical miles with a crew of three,
- continuous cruise speed of 250 knots,
- dash speed of 275 knots,
- seating capacity for 24 combat equipped troops and 2 crewmen, and
- external cargo lift capability of 10,000 pounds.

Additional requirements were set in the areas of (1) readiness, reliability, and maintainability, (2) survivability and crashworthiness, (3) shipboard compatibility, and (4) adverse weather operations. The requirements also specified an aircraft empty weight guarantee that the contractor must demonstrate based on the average weight of the first four production aircraft.

Laboratory and ground tests conducted as of May 1989 did not identify any significant technological problems with the design or operation of the aircraft, according to Navy and contractor officials. As of August 1989, contractor flight testing, which began in April 1989, had not shown any significant performance problems.

As of early 1989, the aircraft's empty weight was the only unmet specification requiring a major contractor effort to resolve. Navy officials estimated that without weight reduction measures, developmental aircraft will exceed the Marine Corps production version target of 32,052

pounds by about 2,250 pounds. This estimate considered that the developmental aircraft was about 800 pounds over the weight target and, historically, other aircraft have experienced weight increases of about 1,450 pounds during engineering development. To correct this problem, the contractors formed a weight reduction team that as of February 1989 had identified weight reduction measures totaling 1,948 pounds. The team was developing additional design changes to eliminate the remaining excess weight of about 300 pounds. Nonetheless, even with the remaining excess weight, Navy officials were confident that the V-22 engines would have sufficient power to compensate for related performance loss with only a minor reduction in the aircraft's range.

The V-22 engines had previously been overweight, were running hot, and were exceeding required fuel consumption. However, according to Navy officials, the engines now meet all performance specifications except one. The one exception is that the latest developmental engines exceed the temperature and fuel consumption specification by up to 15 degrees Fahrenheit and 1.5 percent, respectively, while operating at a low power level.

Cost

From December 1986 through December 1988, total program costs decreased by about $3.8 billion (escalated dollars). This reduction occurred primarily because the number of aircraft to be produced during the production phase decreased from 913 to 657. The cost estimate would have decreased further without offsetting cost increases due primarily to a change in the program's acquisition strategy and a 2-year stretch-out of the procurement period.

V-22 acquisition costs as of December 1986 and December 1988, adjusted for all cost changes encountered during fiscal years 1987 and 1988, are shown in table II.4.

Table II.4: V-22 Acquisition Costs

Dollars in millions

Item	Dec. 1986	Dec. 1988
Number of aircraft[a]	919	663
Research and development		
1986 dollars	$2,443.7	$2,471.0
Escalated dollars	2,625.2	2,660.5
Procurement[b]		
1986 dollars	20,629.3	17,559.9
Escalated dollars	27,037.1	23,194.9
Total acquisition[b]		
1986 dollars	23,073.0	20,030.9
Escalated dollars	29,662.3	25,855.4
Program unit cost		
1986 dollars	$25.1	$30.2
Escalated dollars	32.3	39.0

[a]Includes six full-scale development aircraft.

[b]Includes estimate for construction costs.

The quantity reductions occurred because the Army canceled its planned buy of 231 aircraft and the Air Force lowered its planned buy from 80 to 55 aircraft. Budget constraints prompted the Army's decision, whereas the Air Force's decision was based on a review of its special operations mission requirements.

Despite the V-22 program being deleted from the President's amended fiscal year 1990/1991 budget proposal, the Marine Corps still considers the program its highest priority and still hopes to buy 552 production aircraft. The Navy's revised V-22 procurement cost estimate reflects not only the quantity reductions but also the associated efficiency loss caused by producing fewer aircraft.

The V-22's current total cost estimate includes cost increases of $1.7 billion (escalated dollars) for changing from a dual sourcing to a coproduction procurement strategy and $258 million (escalated dollars) for stretching out the procurement schedule by 2 years. Initially, the Navy planned to have Bell and Boeing compete for the larger share of the production buys starting with lot 1 in fiscal year 1991 because it believed that dual sourcing was the most cost-effective strategy. However, this strategy required an additional $600 million in up-front production money for tooling and technology transfer so that both contractors could independently produce the aircraft. In developing the initial fiscal

year 1990/1991 budget, DOD only approved funding to support a coproduction strategy, which does not require this up-front expenditure. Also, at that time, before the Secretary of Defense recommended canceling the program, DOD directed the Navy to buy fewer aircraft each year, which stretched out the procurement schedule from 1999 to 2001 and further increased program costs.

When the Navy proposed a 1-year delay in the initial limited production decision, it also recommended that it be allowed to return to a dual sourcing procurement strategy starting with lot 1, which, under this schedule, would be in fiscal year 1992. According to this proposal, the Navy would require the additional $600 million for tooling and technology transfer but over a 3-year period. It would not require the $1.4 billion for initial limited production that was included in the original fiscal year 1990 budget until fiscal year 1991. DOD did not approve the Navy's proposal and recommended that the V-22 program be terminated.

Uncertainty Over Most Cost-Effective Procurement Strategy

Although DOD has recommended that the program be canceled, there is still uncertainty about which procurement strategy would be the most cost-effective. While the initial fiscal year 1990 budget request reflected a coproduction strategy, the Navy contends that dual sourcing would result in lower overall program costs, and it proposed awarding dual source contracts for production lot 1 in fiscal year 1992. However, a recent DOD Inspector General report concluded that a dual source strategy requiring both contractors to tool-up is not the most effective strategy for the reduced procurement quantities. The Navy disagreed with this conclusion and continues to support dual sourcing as the most cost-effective procurement strategy.

Recent GAO Reports

DOD Acquisition Programs: Status of Selected Systems (GAO/NSIAD-88-160, June 1988).

DOD Acquisition: Case Study of the Navy V-22 Osprey Joint Vertical Lift Aircraft Program (GAO/NSIAD-86-45S-7, July 31, 1986).

Sea Lance Antisubmarine Warfare Standoff Weapon

Sea Lance will be a supersonic antisubmarine warfare (ASW) standoff weapon capable of being launched from submerged submarines and surface ships equipped with vertical launch systems. It will consist of a quick-reaction, long-range missile that will transport an advanced lightweight torpedo—the MK-50—to the target area and release it to seek and destroy enemy submarines. It is intended to replace the submarine rocket nuclear depth charge used on submarines and the vertical launch antisubmarine rocket used on various surface ships.

The Sea Lance entered full-scale development in April 1986, and since that time it has undergone two major program changes. One reversed the priority of developing the nuclear variant first to developing the conventional variant first and the other resulted from the decision to return to an earlier plan to place Sea Lance on surface ships before placing it on submarines. As a result, the program has experienced significant delays and cost increases.

The Sea Lance conventional variant is scheduled for a limited production decision in June 1992. The Navy estimates the system's development, procurement, and associated construction costs to be $3,344.0 million (escalated dollars). This does not include the cost of the MK-50 torpedo because Sea Lance is only one of many ways the MK-50 can be used.

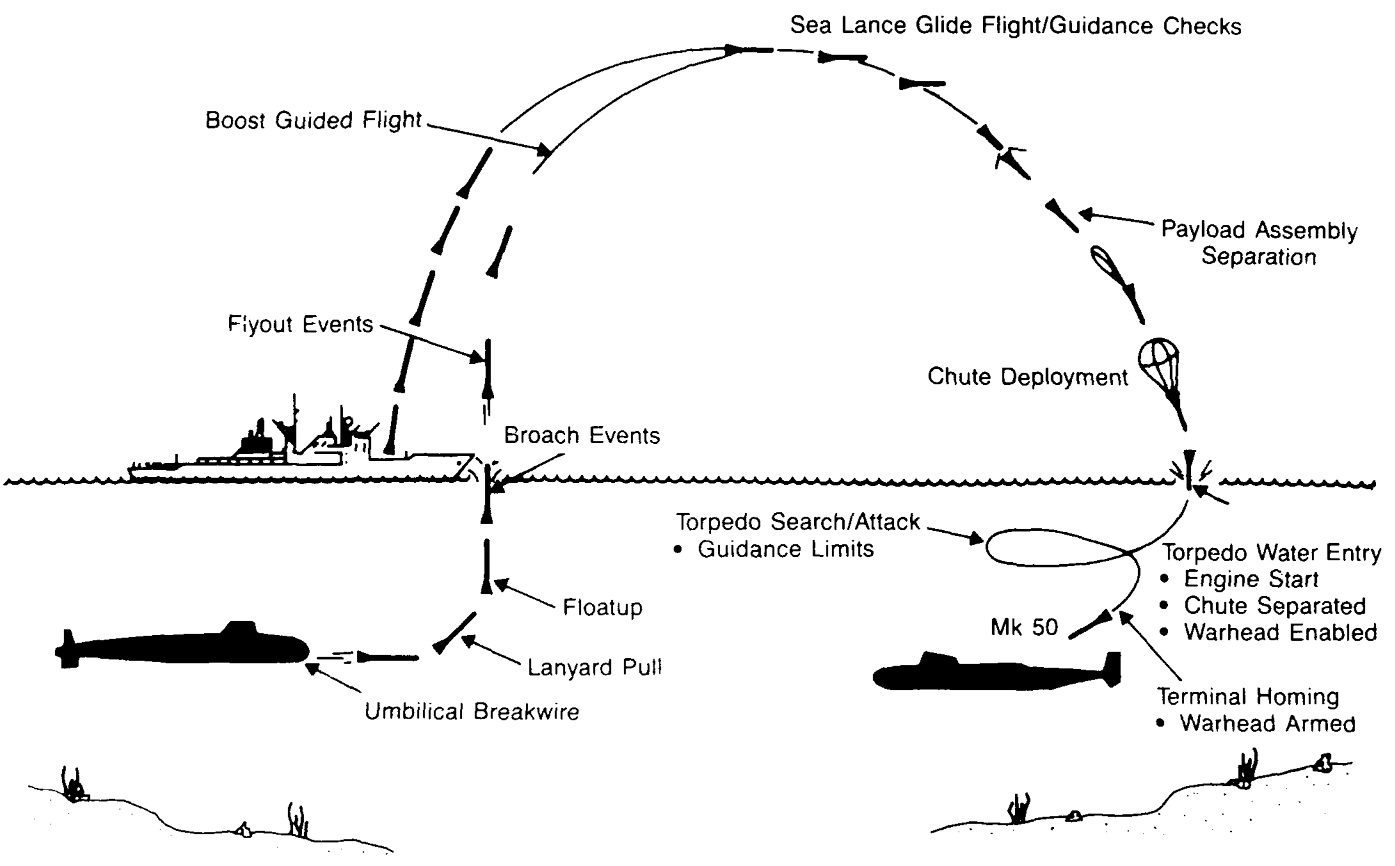
Background

The Navy expects the Sea Lance to be a common use, quick-reaction, long-range, antisubmarine weapon that is compatible with existing and planned submarine and surface sensors and combat control systems. It will be used on CG-47 class cruisers and DD-963 and DDG-51 class destroyers equipped with vertical launch systems and the MK-116 ASW fire control system. It will also be used on SSN-637, SSN-688, and SSN-21 attack submarine classes to replace the submarine rocket missile that is to be retired during the 1990s.

Sea Lance will have adapters for use on submarines and surface ships. The submarine adaptor will consist of a composite capsule that provides physical compatibility with the submarine, environmental protection for the missile, and buoyancy to bring the weapon to the surface. Following tube launch from the submarine, the encapsulated missile will float to the surface where the capsule's forward closure will be explosively removed and the rocket motor will ignite, sending the Sea Lance to target areas. Surface ships equipped with the MK-41 vertical launch system and the MK-116 ASW fire control system will have a surface launch

adaptor for integration of the missile with the vertical launch canister. The canister and missile adaptor will provide physical compatibility with the surface ship's vertical launch system and environmental protection for the missile. Figure II.4 shows the Sea Lance system concept.

Figure II.4: Artist's Conception of Sea Lance System Concept



Requirements

The Soviet Union has improved the design, performance, and countermeasure capabilities of its submarines, making them quieter, faster, and more survivable. Modern Soviet submarines, such as the SIERRA, OSCAR, AKULA, and ALFA classes, present a formidable threat to the U.S. Navy. If the Soviets can successfully target their existing long-range weapons, they could attack U.S. submarines at standoff ranges. Since existing Navy weapons are being phased out, the Navy believes developing its long-range ASW standoff weapon is necessary.

The Navy identified a need for a submarine-launched ASW standoff weapon and began forming a project office in early 1978. In 1980 the Deputy Secretary of Defense approved a mission element needs statement for an ASW standoff weapon. In 1981 the submarine standoff weapon program was combined with a surface ship standoff weapon program. The submarine program was split again in 1982, and in December 1982 the Sea Lance entered the demonstration and validation phase as a submarine-launched weapon.

The Sea Lance is being developed to counter both current and projected submarine threats specified in the August 1988 Navy ASW System Threat Assessment Report. It is designed to increase overall ASW system effectiveness and reduce counterattack vulnerability by limiting the period of engagement with the enemy.

Schedule

Since 1986, the Sea Lance program has experienced two major program changes that delayed development and technical and operational testing. The first occurred in July 1986 when the Navy decided to develop the conventional variant after the contract for the nuclear variant had been awarded, deferring the full-scale development decision on the nuclear variant until after the decision on limited production of the conventional variant. The second occurred in April 1988 when the Navy returned to an earlier plan and decided that initial launch capability of Sea Lance would be from surface ships rather than submarines. These decisions, coupled with reduced fiscal year 1989 funding, delayed not only the development of Sea Lance for submarines by 15 months but also first flight by 1 year. Program officials consider the current schedule risk to be low to moderate. Table II.5 shows these milestone changes.

Table II.5: Sea Lance Program Schedule

Event	1986 program	Program as of June 1989
Demonstration and validation phase	Dec 1982	Dec 1982
Full-scale development decision	Apr 1986	Apr 1986
Full-scale development contract award	July 1986	July 1986
Limited production decision	Dec 1990	June 1992
Limited production contract award	Jan 1991	Oct 1991[a]
Start technical evaluation (submarine)	Oct 1990	Nov 1992
Start technical evaluation (surface)	N/A	June 1992
Start operational evaluation (submarine)	Jan 1991	Feb 1993
Start operational evaluation (surface)	N/A	Sept 1992
Full rate production decision	Oct 1991	Jan 1994

[a]The Navy plans to award an advanced procurement contract in October 1991, with an option to begin limited production shortly after the June 1992 limited production decision is made.

Performance

The Navy plans to test and evaluate the Sea Lance missile system for surface ship launch before limited production begins. A total of 23 contractor test and evaluation flights and 5 joint developmental and operational test flights will be conducted to support the limited production decision. In addition, the Navy plans to conduct 10 technical evaluation test flights and 20 operational evaluation test flights to support the full-rate production decision. The test and evaluation master plan, approved February 2, 1989, states that both the contractor and the Navy will conduct extensive software tests and that all test scenarios will emphasize operational realism, including short, medium, and long-range targets. The Navy will conduct independent validation, verification, and certification tests of flight hardware control algorithms and operational computer programs before each missile flight using similar simulation.

Weapon system testing to date has concentrated on the submarine integration and missile component assembly testing. In April 1988 the program was restructured to accelerate surface ship integration. The program office has established technical and operational performance thresholds for both surface ships and submarines. Sea Lance will achieve initial operational capability first on surface ships. Since the submarine version is similar to the surface version, the surface version's operational evaluation also will support a recommendation for low-rate initial production of the submarine version. The Navy plans to support its full-rate production decision with operational evaluations of the submarine version of Sea Lance.

According to the Navy, because technical risk associated with Sea Lance development was reduced by using technology developed for other missile systems, full-up flight tests were deferred until full-scale development. Boeing tested both system and subsystem components using an operational mock-up unit during the demonstration and validation phase. Tests included missile flight simulations that demonstrated guidance and control algorithms with actual components of avionics and flight control systems. Prequalification static firing rocket motor tests and a launch test with short burning rocket motor and full avionics also were conducted. Boeing will continue to use the operational mock-up unit for both pre- and post-flight simulations for test prediction and specification verification. A senior program official observed that although use of such a mock-up unit was not unusual, it could not replace a full function flight test.

The Navy does not consider technological development issues to be high risk; however, it does recognize that key performance areas need to be demonstrated. Some of these areas include whether

- the canister or capsule systems will provide adequate protection for the missile;
- the rocket motor can provide the thrust and total impulse required to meet flight time and range requirements;
- the canister and capsule subsystems will function properly to permit the missile to exit;
- the missile avionics and flight control systems will direct the missile to follow the intended flight path; and
- the weapon will meet the specifications for accuracy, range, missile ignition to splash time, reliability, and weight.

For Sea Lance to be effectively used at longer ranges on ships without helicopters, significant improvements are needed in target detection capabilities. Such ships will rely primarily on the surface ASW systems improvement program (SQQ-89I) to be able to detect submarines within the outer limits of Sea Lance's range, and the Navy is still developing these capabilities. The surface ASW systems improvement program has experienced delays and setbacks in its development, primarily because of the high technological risks.

In addition, the Navy is concerned about the need to better identify the Sea Lance in its flight trajectory so that it does not get shot down by friendly antimissile weapons. The Naval Sea Systems Command is currently addressing this concern.

Cost

The Sea Lance program has experienced significant increases in development, procurement, and military construction costs (see table II.6). Because the Navy has decided to use Sea Lance on surface ships as well as submarines, the quantities to be procured have increased substantially, resulting in higher acquisition costs but lower unit costs. The Navy has classified the quantities and unit costs. These costs do not include the MK-50 torpedo payload costs.

Table II.6: Sea Lance Acquisition Costs
(Escalated Dollars)

Dollars in millions

Item	Dec. 31, 1986 estimate	Dec. 31, 1988 estimate
Development	$858.4	$1,083.1
Procurement	1,569.5	2,229.8
Military construction	23.0	31.1
Total	**$2,450.9**	**$3,344.0**

The cost increases also reflect the accelerated development of the conventional variant, the deferral of further development of the nuclear variant, and the decision to use Sea Lance on surface ships. Program officials expect to meet cost goals if funding continues as budgeted. However, according to program officials, any future budget cuts would result in delaying the initial operational capability of both surface and submarine missiles.

As previously stated, the Navy awarded a full-scale development contract in July 1986 for $380 million to develop a submarine-launched Sea Lance with a nuclear variant and a conventional variant to follow. In August 1986 the Secretary of the Navy deferred development of the nuclear variant and accelerated the MK-50 variant; however, the Navy did not modify the contract and reduce full-scale development costs to $378 million until March 1988. The following month, in April 1988, the Navy combined the surface ship and submarine programs, but a modified contract to include full-scale development for both surface and submarine systems is not expected until the fall of 1989. On March 27, 1989, the Defense Acquisition Board directed the Sea Lance program office to resubmit baseline cost estimates for the combined program at least 60 days prior to award of this modified contract.

Recent GAO Reports

None.

AN/BSY-1 Submarine Combat System

The AN/BSY-1 submarine combat system being installed on improved Los Angeles class nuclear attack submarines (SSN-688s) is a computer-aided detection, classification, and tracking system consisting of acoustic sensors, fire control, and weapons launch hardware and software. According to the Navy, the AN/BSY-1 will address shortfalls in existing systems and provide these submarines the capabilities needed to meet expanded mission requirements and counter the changing Soviet threat. The Navy expects development and procurement of 24 combat systems and associated equipment for the program to cost about $4.7 billion (escalated dollars). Life-cycle costs are estimated at $12.1 billion.

Notwithstanding that the AN/BSY-1 is scheduled for a full-scale production decision in October 1990, the Navy plans to have awarded contracts for all 24 systems by November 1989. Concurrent development and production were approved to meet ship construction schedules. The Navy believes the system will be operationally effective, but technical and operational performance thresholds have not been demonstrated. Until these tests are conducted, the Navy will not know the extent to which the AN/BSY-1 will be an improvement over existing systems, however, at this time there are no indications that the AN/BSY-1 will not achieve its performance goals.

Background

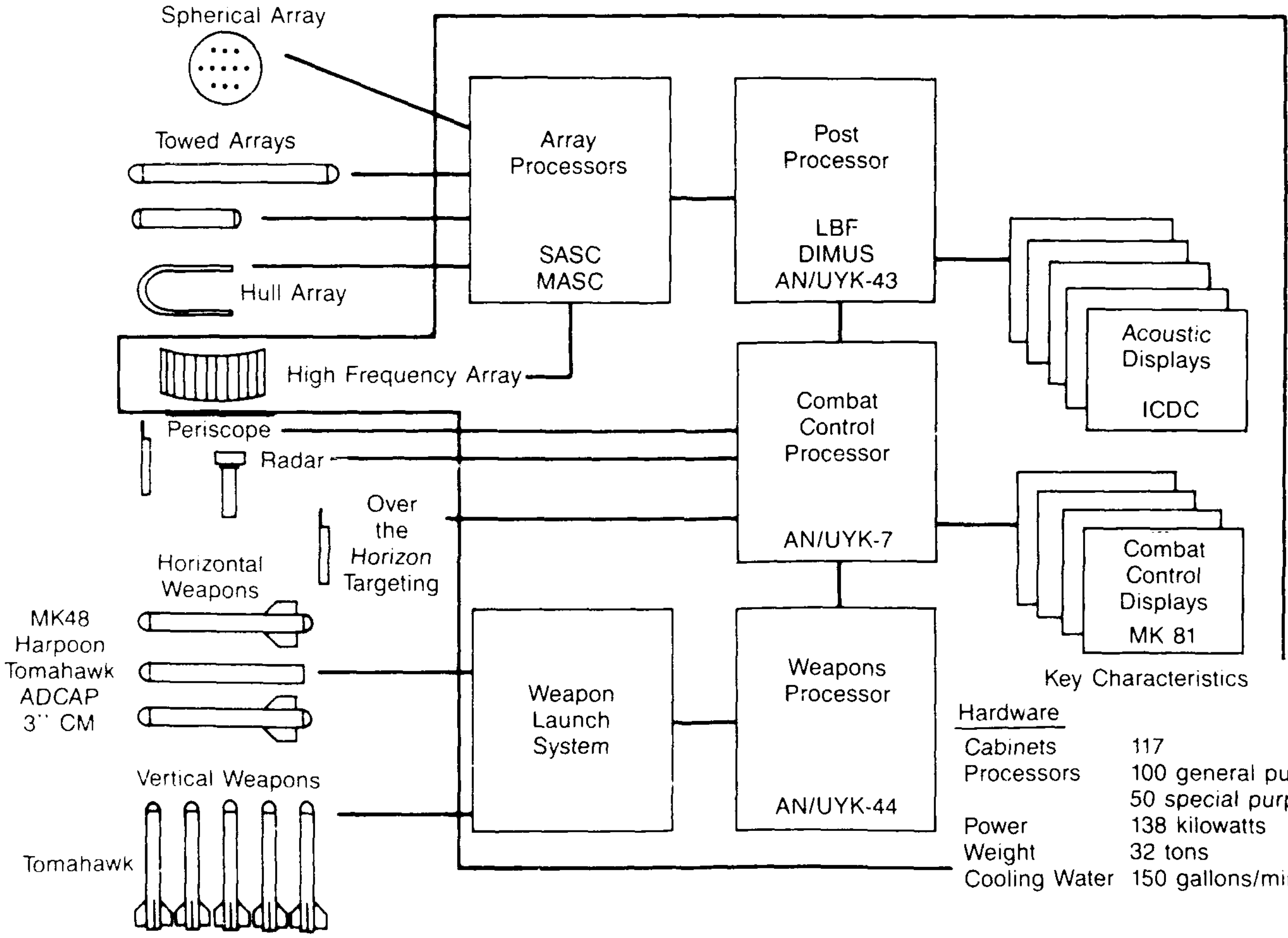
The AN/BSY-1 evolved from the Submarine Advanced Combat System program the Navy initiated in 1980. Because of cost, schedule, and technical problems, the program was restructured several times and finally became two programs—the AN/BSY-1 system for the improved SSN-688 class submarines and the AN/BSY-2 system for the SSN-21 class submarines. The AN/BSY-1 is expected to provide improved capabilities in the acoustic and weapon launch areas, but due to previous problems and program restructuring, it will be less capable than originally planned under the earlier program. To take advantage of new technology and system functions, the Navy is developing an AN/BSY-1 improvement program.

In October 1983 DOD approved full-scale engineering development and concurrent initial production of five systems. Although still in full-scale development, in May 1986 DOD approved concurrent production of 15 additional systems and in March 1989 it approved two more systems. Pending DOD approval in October 1989 of the last two systems, the Navy plans to have all 24 systems under contract by November 1989. International Business Machines Corporation (IBM) is the prime contractor for the AN/BSY-1.

There are currently two versions of the system. Preliminary product baseline systems are being installed on four submarines, SSN-751 through SSN-754, which will give those submarines limited self-defense capabilities (acoustic, safety, and weapon firing functions). However, until the system is upgraded, these submarines will not have offensive capabilities. The second version, the product baseline system, will have full performance capabilities and will be installed on the 20 remaining improved submarines, starting with SSN-755. These capabilities will be added to the SSN-751 through SSN-754 during each submarine's post shakedown availability[7] and will include a software upgrade, a replacement of the old AN/UYK-7 computer with the AN/UYK-43 computer, the addition of a second signal processor, and a color display console for under ice operations. Figure II.5 shows a schematic of the product baseline AN/BSY-1 combat control and acoustics system.

[7] An availability is an assignment of a ship to a repair facility for repairs or maintenance. A post shakedown availability occurs after a newly built, activated or converted ship has completed its shakedown cruise. These maintenance periods are normally for a 3-month period. The Navy estimates the post shakedown availability for the SSN-751 through SSN-754 will be 9-10 months each.

Figure II.5: AN/BSY-1 Combat Control and Acoustics System



Key Characteristics

Hardware	
Cabinets	117
Processors	100 general purpose 50 special purpose
Power	138 kilowatts
Weight	32 tons
Cooling Water	150 gallons/minute

Requirements

Program requirements stem from the need to address shortfalls in existing submarine combat systems and the Soviets' significant gains in submarine quieting and acoustic sensors. The Navy recognized the need for a new combat system in 1980 when it began the Submarine Advanced Combat System program, and it reaffirmed the need in 1985.

The product baseline system is expected to provide increased performance capabilities that will allow improved SSN-688 submarines to meet added surveillance, strike warfare, and mine warfare missions and to

counter the threat posed by Soviet submarine quieting and acoustic sensor gains. The Navy considered several other designs but determined that only the AN/BSY-1 could be developed or modified to meet its needs within budget and schedule constraints.

The product baseline system is being designed to improve data processing and management capabilities. With the use of the new AN/UYK-43 computer, certain tasks (e.g., searching for, detecting, classifying, and tracking targets) will be more automated. The system also will include new improved consoles, data displays, and additional software. It will allow system operators to perform multiple tasks, address multiple targets concurrently, and process tactical data faster and more accurately than the current system. Collectively, these capabilities will reduce the response time between initially detecting a target and launching a weapon. According to the Navy, other combat systems cannot offer this capability.

Schedule

Timely delivery of the AN/BSY-1 submarine combat systems to the shipyards is essential to allow the shipbuilder to meet its ship delivery schedules. However, early AN/BSY-1 development difficulties and other design problems led to late delivery of the combat systems and thus to ship construction delays. This, in turn, led to shipbuilder claims against the Navy. Subsequently, a labor strike at one of the shipyards led to further ship construction delays, and, as a result, the Navy and IBM revised the AN/BSY-1 delivery schedules to correspond to new ship delivery schedules. The first five systems have been delivered to the Navy as stated in the revised delivery schedule—four preliminary product baseline systems have been installed and one system with full performance capability is being retained at IBM until the shipbuilder is ready for it. However, IBM did not deliver the system upgrades necessary to make the first four systems fully capable as originally scheduled. These upgrades will be delivered in time to be installed during each submarine's post shakedown availability. According to the Navy, timely delivery of the remaining systems is not expected to be a problem.

Legislation (10 U.S.C. 138 and 2366) requires that major defense acquisition programs are to complete operational testing and evaluations before proceeding to a full-rate production decision. AN/BSY-1 performance will not be demonstrated through technical or operational testing until after contracts have been awarded for all 24 systems and several systems have been accepted by the Navy. The Navy is planning to conduct technical and operational evaluations starting in March and August

1990, respectively, and to make a full-rate production decision in October 1990; however, it is unclear what will be accomplished at this full-rate production review. The following table shows the current AN/BSY-1 schedule.

Table II.7: AN/BSY-1 Combat System Schedule

Event	Feb. 1986 program	April 1989 program
Full-scale development and concurrent initial production decision for 5 systems	Oct. 1983	
Limited production decision for 15 systems	May 1986	
Limited production decision for 2 systems	Nov. 1988	Mar. 1989
Operational assessment based on computer simulation	July 1988	July 1989
Limited production decision for last 2 systems	Nov. 1988	Aug. 1989
First upgrade to full performance system completed (SSN-751)	Sept. 1988	Nov. 1989
Start technical evaluation (SSN-751)	Jan. 1989	Mar. 1990
Complete technical evaluation	June 1989	Aug. 1990
Start operational evaluation	June 1989	Aug. 1990
Full-rate production decision	Oct. 1989	Oct. 1990
Complete operational evaluation	Dec. 1989	Jan. 1991

Performance

The AN/BSY-1 combat system replaces the AN/BQQ-5 sonar and CCS MK-1 fire control systems currently installed on SSN-688 class submarines. The Navy is confident that, once the full product baseline AN/BSY-1 system is complete, it will be an improvement over existing systems. The Navy has conducted preliminary tests on some AN/BSY-1 subsystems,[7] but, until a complete AN/BSY-1 is subjected to operational and technical tests, the Navy will not know with certainty how capable the system will be or whether it will be an improvement over older systems.

The first four systems accepted by the Navy are not fully capable systems. Thus, submarines equipped with these first four systems have only limited self-protection capabilities. As a result, they will not normally be operated outside U.S. waters.

[7] According to the Navy, the SSN 751 fired 12 torpedoes with 9 hits during a weapon system accuracy test and tactical weapons training and certification firings. Three torpedo failures occurred. According to the AN/BSY-1 program manager, this performance is above the fleet average. The passive sonar also tracked a submerged target, which simulates the acoustic signature of a submarine, at ranges greater than any previous submarine.

In June 1988 the Navy's Board of Inspection and Survey conducted an underway acceptance sea trial of the SSN-751 with a less than fully capable AN/BSY-1 system. Its July 15, 1988, report listed 20 deficiencies of such significance that the ship's ability to perform its mission was degraded. Most of these deficiencies related to the AN/BSY-1 combat system and primarily existed because the system upgrade to full performance capability had not been installed. The Board recommended that a retrial be conducted after the upgrade is installed, but a retrial is not planned at this time. As a result, it is unknown whether the submarine will be able to accomplish its missions and counter the threat. The Navy, however, is confident that the AN/BSY-1 systems will be operationally effective on the basis of performance to date of the SSN-751 and SSN-752.

Cost

Total estimated program costs have increased 125 percent since fiscal year 1986 because of the Navy's decision to buy more systems and because the operating and support cost estimate has tripled. In February 1986, the Navy estimated the AN/BSY-1 operating and support cost at $1.6 billion for 19 systems, trainers, and spares. In November 1988, the Navy increased its requirements to 24 systems and estimated operating and support cost at $7.4 billion for these systems and associated equipment. (See table II.8.)

Table II.8: AN/BSY-1 Life-Cycle Cost Estimates (Escalated Dollars)

Dollars in millions

	Feb. 1986 estimate	Nov. 1988 estimate	Difference
Quantity	19	24	5
Development	$1,227.7	$1,211.0	$−16.7
Production	2,588.3	3,513.8	925.5
Acquisition cost	**3,816.0**	**4,724.8**	**908.8**
Operation and support	1,578.1	7,424.7	5,846.6
Life-cycle cost	**$5,394.1**	**$12,149.5**	**$6,755.4**

According to an AN/BSY-1 program official, funding cuts in fiscal year 1988 and a decline in program office civilian personnel costs caused development cost estimates to decline. Production costs increased due to the addition of five AN/BSY-1 systems, six wide aperture arrays,[a] maintenance trainer spares, and modular screening and repair activity test

[a]A wide aperture array is a hull mounted sensor used to locate targets and calculate the target's range and motion

program sets. In addition, cost estimates increased because more current data were available. These increases were offset by reductions to spares and facility requirements.

The substantial increase in the operating and support cost is attributed to (1) using a revised model that changed some assumptions made in developing the February 1986 estimate—about $1.6 billion, (2) including additional operating expenses of about $1.5 billion, and (3) correcting the number of system operating years from 133 years to 613 years, for an increase of about $2.7 billion.

Recent GAO Reports

Submarine Combat System: Technical Challenges Confronting Navy's Seawolf AN/BSY-2 Development (GAO/IMTEC-89-35, Mar. 13, 1989).

SUBACS Problems May Adversely Affect Navy Attack Submarine Programs (GAO/NSIAD-86-12, Nov. 4, 1985).

Air Force Programs

Peacekeeper Rail Garrison

The Peacekeeper Rail Garrison concept emerged in 1988 as DOD's highest priority basing mode for intercontinental ballistic missiles (ICBMS). Under the concept, a force of 50 Peacekeeper missiles will be placed on 25 trains, each carrying two missiles. The Air Force remains confident that it can achieve a successful system by integrating existing missile and railroad technology. System performance, however, will not be demonstrated until the system progresses through the developmental cycle. The Air Force estimates that rail basing will cost $6.8 billion (escalated dollars).

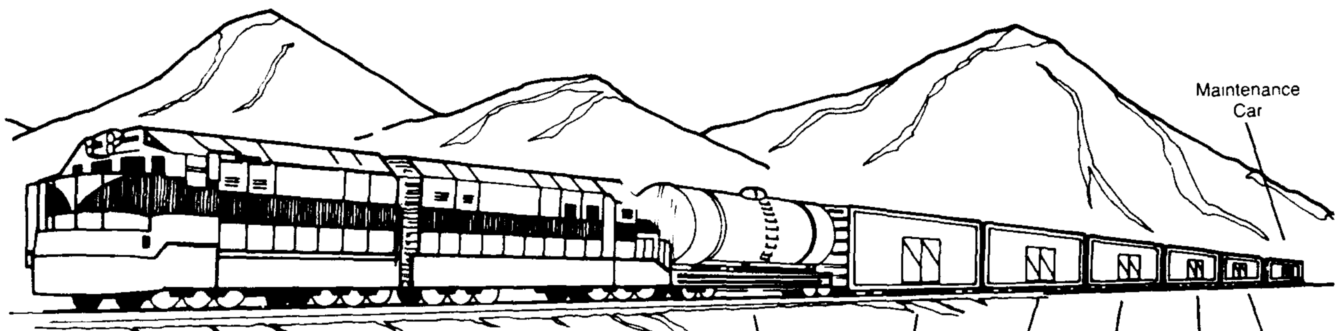
Whether the Rail Garrison concept retains its high priority status is uncertain—congressional approval to deploy Peacekeeper missiles in Rail Garrison basing has not been given and the program's acquisition pace has been slowed. Also, the Air Force has extended the Rail Garrison program's initial and full operational capability dates by 6 months, to June 1992 and June 1994, respectively, because of budget constraints. These dates could change further based on the pending decision by the Congress. Thus, the cost, schedule, and performance goals of the program are subject to change and the following assessment of status should be viewed within that context.

Background

The principal mission of the Peacekeeper Rail Garrison weapon system is to deter nuclear and conventional attacks against the United States, its allies, and any nation whose security is vital to U.S. interests. The weapon system is intended to combine the capabilities of the Peacekeeper missile, such as payload, range, and accuracy, with the survivability and flexibility inherent in the Rail Garrison basing approach. DOD believes that rail basing of the Peacekeeper will enhance the U.S. strategic posture significantly by providing a more survivable land-based system.

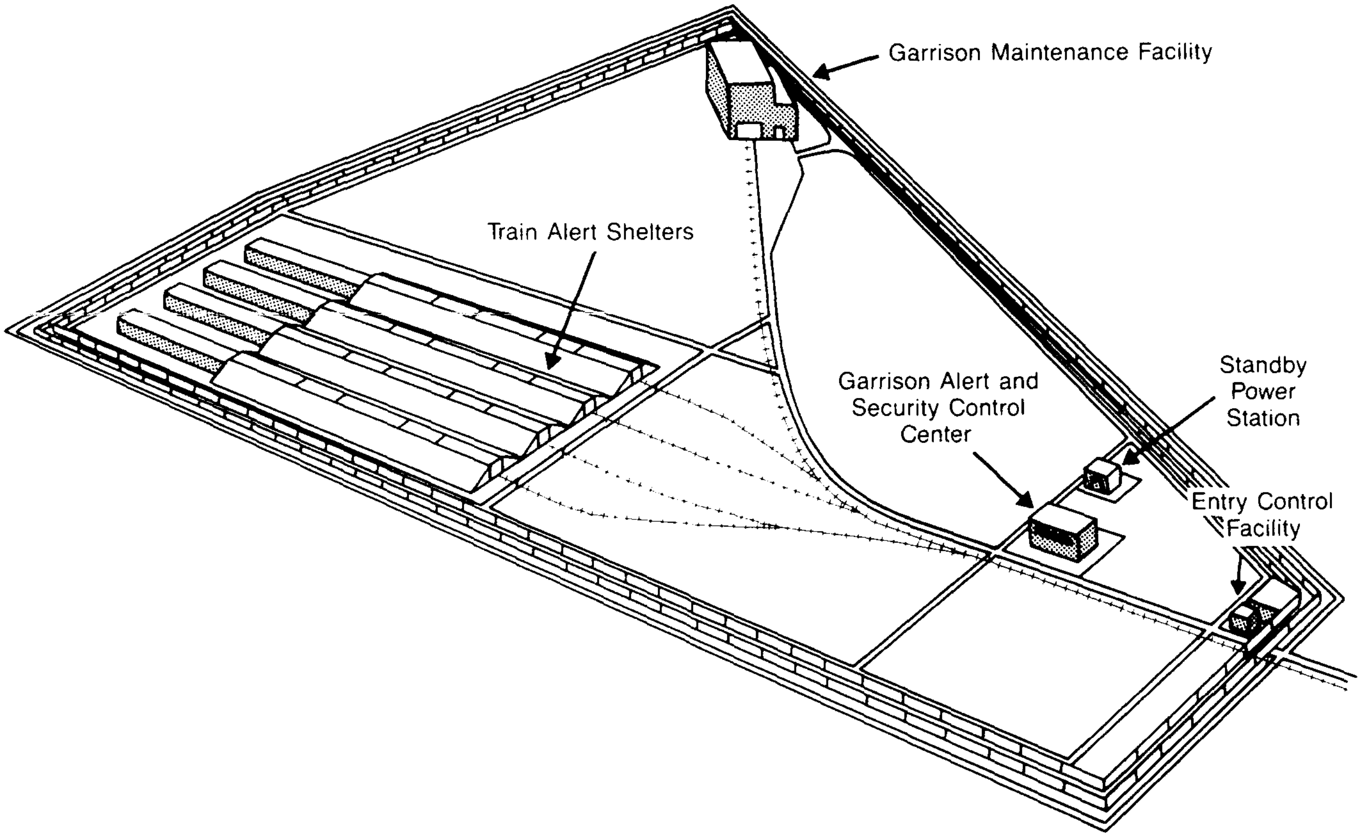
The Peacekeeper Rail Garrison basing system will consist of a train having two locomotives; two missile launch cars; one launch control car; two security, personnel, and support cars; one maintenance car; and a fuel car. (See fig. III.1.) The Air Force may add more rail cars, as required, for operations. The train's external appearance will resemble commercial freight rail equipment as much as possible.

Figure III.1: Peacekeeper Rail Garrison Train



The trains will be parked inside secure garrisons at the main operating base at F.E. Warren Air Force Base, Wyoming, and at yet to be selected Air Force bases throughout the continental United States, with up to four trains at each garrison. Each garrison will include train alert shelters for housing the trains and a maintenance area/facility that will provide the capability to remove/replace the missile guidance and control set and the reentry system. All Peacekeeper missiles will be on continuous alert and will move onto the nation's railways only in the event of national need. If necessary, the missiles can be rapidly launched from within the train alert shelters while in the garrisons. Figure III.2 shows a typical Rail Garrison layout.

Figure III.2: Typical Rail Garrison Layout



The program office divided Rail Garrison development into three major contracts. The first contract, a basing test and system support contract, was awarded to Boeing Aerospace Company in September 1987. The contract's purpose is to (1) design, develop, and fabricate unique transportation and handling equipment, test facilities, test support equipment, and maintenance car, (2) modify the train's locomotive to provide some protection against certain threats, and (3) design the operational garrison. The second contract was awarded to Westinghouse Electric Corporation in May 1988 to develop the missile launch car. The third contract was awarded to Rockwell International in May 1988 to develop the launch control and security cars, the launch control and communication systems, and the train security system.

Requirements

The President instructed DOD on December 19, 1986, to begin the development of a Rail Garrison basing system for the Peacekeeper missile. The Congress had limited Peacekeeper missile deployment in Minuteman silos to 50 missiles and had instructed DOD and the Air Force to develop more survivable concepts for Peacekeeper basing. The Rail Garrison concept will enable the Air Force to deploy 50 Peacekeeper missiles on rail cars and accomplish survivability through dispersal onto the commercial railroad network in time of national need.

OSD and the Air Force believe that Rail Garrison will meet the requirements for additional warheads in a survivable basing mode. The requirement for the system was validated when Air Force Headquarters approved the Strategic Air Command's formal statement of operational requirements document, dated June 1988.

Schedule

On May 13, 1988, the Secretary of Defense approved the advancement of the Peacekeeper Rail Garrison Program into full-scale development. The program office completed its system design review process, which was made to assure that it and the three contractors agreed upon the basic system requirements, in September 1988. On the basis of this review, all three contractors were authorized to proceed toward the preliminary design review phase. This represents the next key design phase during which the program office plans to refine the system design further. Preliminary design reviews started in February 1989 and ran through June 1989.

The initial operational capability and full operational capability dates were each extended by 6 months, to June 1992 and June 1994, respectively, to accommodate budget constraints. The dates of selected major program milestones, scheduled as of February 1989, are listed in table III.1.

Table III.1: Approved Program Milestones as of February 1989

Milestone	Date
Start of full-scale development	May 1988
System design reviews	Sept. 1988
Preliminary design reviews	Feb. - June 1989
Critical design reviews	Dec. 1989 - Mar. 1990
Initial production decision	Apr. 1990
Basing verification missile tests	July 1991 - May 1992
Full-rate production decision	Mar. 1992
Initial operational capability[a]	June 1992
Full operational capability	June 1994

[a]Initial operational capability is defined as one train on alert with two missiles, plus one training train available to the Strategic Air Command.

Previously, we reported that the schedule was optimistic and that concurrency—the overlap of developmental and production phases—existed in the program. For example, at the time of the full-scale development decision in May 1988, the program office believed that achieving a December 1991 initial operational capability date required an ambitious schedule to perform all the activities to support deployment of Peacekeeper missiles on trains. To meet that challenge, the program office developed an acquisition schedule that provided for the start of production 2 years before development contracts were complete—train car development contracts extend into mid-1992, even though a production decision was scheduled for early 1990. As demonstrated in other Air Force acquisition programs, unless concurrency is well planned and controlled, it can cause cost, schedule, and performance problems.

The program office expects that the results of developmental testing of preliminary designs of individual subsystems will provide adequate information to support an April 1990 initial production decision. However, by then the Air Force will have completed only about 2 years of the 4-year test program planned at the beginning of full-scale development. At that time, the Air Force will not have conducted most systems' integration testing, all basing verification missile flight tests, and most of the operational test and evaluation effort. Program officials believe that Rail Garrison's low technical risk combined with the planned sequential testing and evaluation program represent a reasonable risk in achieving the initial operational capability date.

As previously discussed, dates for initial and full operational capabilities have been extended by 6 months, but the program milestones preceding these two dates have remained basically unchanged.

Additionally, the fiscal year 1990 funding request was reduced from about $2.4 billion to about $1.2 billion due to competing demands from other Air Force programs. Taken collectively, these issues make it unclear how the overall program schedule will be affected.

Performance

The Rail Garrison involves requirements not common to silo-based ICBM systems such as stabilization and land navigation. However, the Air Force believes that the Rail Garrison option offers a low-risk program that is principally an integration effort taking advantage of existing (1) equipment and technology, (2) rail network infrastructure, and (3) Strategic Air Command bases and ICBM infrastructure, such as nuclear weapons storage areas and strategic command, control, and communications systems.

The Rail Garrison concept entered the full-scale development phase in May 1988, and any conclusive assessment of its technical performance must await the results of planned testing. In particular, certain unique operational effectiveness characteristics associated with mobility on the rail network, such as the capabilities to restore missile accuracy in a specified time frame and to launch from the missile launch car, must be fully evaluated and demonstrated before the effectiveness of the operational concept can be confirmed. These issues are discussed below.

Missile Accuracy Restoration

If the weapon system is moved from secured garrisons onto the rail network before missile launch, it will be necessary to plot precisely each train's new location so that the accuracy required to destroy designated targets can be maintained. The Air Force has established time frames within which system accuracy must be restored. To facilitate accuracy restoration, the Air Force will establish presurveyed locations from which the missiles' guidance systems can be recalibrated. On the basis of studies and analyses and initial rail tests, the Air Force is confident that accuracy can be restored within the time frames at the presurveyed launch locations. However, the tests indicate that additional techniques may be required to plot the trains' new locations within the time frames if missiles are launched from locations other than those that have been presurveyed. The program office plans to conduct a series of tests during 1989 and 1990 to continue to define the effects of movement on system accuracy and to evaluate the means to restore accuracy from anywhere on the rail network.

Missile Launch From a Rail Car

When analyzing and evaluating the capability to launch a missile from a rail car and resume mobile operations after launch, the program office

has to consider such factors as the train's ability to withstand the effects of missile launch and subsequent first-stage ignition and the launch effects on commercial railroad trackbeds. The program office believes that 18 developmental flight tests of the Peacekeeper silo program[1] have provided confidence that the pressures, shock, heat, and noise of first-stage ignition will not create difficulties in the Rail Garrison program. In addition, on the basis of tests conducted during March and July 1988 that used a developmental model of the missile launch car, the program office concluded that the car, track, and roadbed can sustain launch loads. Additional testing is planned during fiscal years 1989, 1990, and 1991 to evaluate, demonstrate, and confirm the capability to launch from a rail car either from the train alert shelter or while dispersed on the rail network.

Railroad Interface

To ensure the mobility necessary for survivability, the Air Force must be confident that enough track to meet the size requirements of the missile train is available. Survivability also depends upon the ability of the Peacekeeper train to operate safely on the available rail network in conjunction with commercial rail traffic.

Preliminary estimates identified about 120,000 miles of 148,000 miles of main line track surveyed that are available for Rail Garrison deployment based on its present size and weight specifications. The Air Force is further refining this estimate by reviewing track segments that may have restrictions and by surveying short line railroads and other connecting segments.

We reported in January 1989 that the current Rail Garrison train car dimensions meet railroad standards. We also reported, however, that the potential for growth does exist—particularly with respect to the weight of the missile launch car—and that increases in rail car dimensions could reduce the amount of suitable track mileage available for deployment. The Air Force is closely managing this issue and believes it will be able to design the system within the railroad standards.

The ultimate goal for interface between Rail Garrison and the commercial rail network is a system that will operate under formal agreements with railroad companies and that will comply not only with railroad operational policies and practices but with government regulations imposed on the railroad industry. The program office expects to finalize

[1] The first 8 of these 18 tests were launched from ground level sites and the last 10 were launched from a silo.

formal agreements with the railroad companies between mid-1990 and mid-1991.

Cost

The Air Force's preliminary 1988 Selected Acquisition Report (SAR) estimates Rail Garrison basing program acquisition costs to be $6.8 billion in escalated dollars. This estimate includes costs to develop and procure train cars and other basing hardware, facility construction, land acquisition, and five basing verification flight test missiles. This estimate is $600 million less than the $7.4 billion estimated in January 1988 and the program office attributed the decrease to better cost estimates. Table III.2 shows the program office's acquisition cost estimate by cost category.

Table III.2: Peacekeeper Rail Garrison Acquisition Costs (Escalated Dollars)

Dollars in billions

Cost category	Jan. 1988	April 1989	Change
Research and development	$2.9	$2.6	$-0.3
Procurement	3.6	3.5	-0.1
Construction	$.9	.7	-0.2
Total	**$7.4**	**$6.8**	**$-0.6**

The Congress appropriated $1.02 billion for the Rail Garrison basing program—$90 million, $332 million, and $600 million in fiscal years 1987, 1988, and 1989, respectively, for research and development. In authorizing the fiscal year 1989 research and development funds, the Congress stipulated that authorization did not constitute a commitment or express an intent by the Congress to provide funds to deploy any Peacekeeper missiles in a Rail Garrison basing mode. In addition, the Congress stipulated that only $250 million of the $600 million could be obligated before February 15, 1989. Furthermore, the Congress requested the President to submit a report to the Committees on Armed Services and on Appropriations between January 21, 1989, and February 15, 1989, on how funds for ICBM modernization would be obligated for the remaining amount. In February 1989 the President advised the Congress that the administration was reviewing various ICBM modernization options and would report its findings to the Congress when completed. Later, the President released all the Rail Garrison funding and decided to redeploy the 50 Peacekeeper missiles currently in silos to trains. The President, however, requested that $100 million of Rail Garrison funds be reprogrammed to the small ICBM program.

The Air Force reduced its fiscal year 1990 Rail Garrison request for research, development, and procurement funds from about \$2.4 billion to about \$1.2 billion to accommodate needs in other programs. According to program officials, the reduced amount for procurement has resulted in Rail Garrison hardware being bought in fiscal year 1991 rather than in fiscal year 1990. Only advanced procurement of materials is planned in fiscal year 1990 to support later production.

Recent GAO Reports

ICBM Modernization: Availability Problems and Flight Test Delays in Peacekeeper Program (GAO/NSIAD-89-105, Mar. 9, 1989).

ICBM Modernization: Status of the Peacekeeper Rail Garrison Missile System (GAO/NSIAD-89-64, Jan. 12, 1989).

ICBM Modernization: Selected Funding Options for the Small ICBM (GAO/NSIAD-88-193, July 7, 1988).

DOD Acquisition Programs: Status of Selected Systems (GAO/NSIAD-88-160, June 30, 1988).

Procurement: Delivery Problems With Inertial Measurement Units (GAO/NSIAD-87-74BR, Dec. 18, 1987).

ICBM Modernization: Status, Survivable Basing Issues, and Need to Reestablish a National Consensus (GAO/NSIAD-86-200, Sept. 19, 1986).

Status of the Intercontinental Ballistic Missile Modernization Program (GAO/NSIAD-85-78, July 8, 1985).

Advanced Tactical Fighter

The Air Force is developing the Advanced Tactical Fighter (ATF) to meet its air superiority requirements in the mid-1990s and beyond. The ATF program is in the demonstration/validation phase, with flight testing of two competing prototype[2] aircraft scheduled to begin in early 1990. A decision to begin full-scale development of the winning contractor team's proposed design, including its proposed avionics suite, is scheduled for December 1990. The program office estimated in May 1989 that the program acquisition cost will total $67.1 billion in escalated dollars. This estimate includes $13.5 billion for research, development, test, and evaluation and $53.6 billion for procurement of 750 aircraft.

The ATF development plan incorporates technological advances in design, materials, propulsion, and electronics to provide an advanced aircraft system superior to any Soviet systems currently postulated for the future. The Air Force has defined broad performance goals, a program schedule, and a cost and weight goal for the aircraft. The cost goal is stated in terms of aircraft unit flyaway cost.[3] During the demonstration/validation phase, the Air Force intends to assess the benefits and the likely costs of incorporating these new technologies and plans to make the necessary trade-off decisions to achieve the program's cost, weight, and performance goals.

As of January 1989, about one-half of the 50-month (October 1986 to December 1990) demonstration/validation phase had been completed, with some critical cost and trade-off decisions and system demonstrations to be completed. Until the completion of the required cost and trade-off studies, engineering analyses, component tests, and prototype demonstrations, the ATF's design and system specifications are subject to change, and the Air Force cannot make an accurate assessment of the ATF's performance capabilities for full-scale development.

At the direction of the Congress, the Navy is evaluating the ATF as a possible replacement for the F-14 fighter aircraft. The Navy will participate in the Air Force's full-scale development source selection process by evaluating proposed designs of a Navy variant to be submitted by each contractor team.

[2] A prototype is the first working article of a new technology or design intended to serve as the pattern or guide for subsequent designs that would be incorporated in a weapon system.

[3] Unit flyaway cost includes all production costs (recurring and nonrecurring) that are incurred in the manufacture of a usable end item. It includes the prime mission equipment (basic structure, propulsion, electronics) and allowances for engineering changes and warranties.

Background

The ATF is being developed as a follow-on to the F-15 aircraft in the air superiority role. It is expected to have new and expanded capabilities, including an ability to cruise at supersonic speeds over long distances, with greater maneuverability, longer range, lower detectability, and improved reliability and maintainability than any existing fighter aircraft.

The ATF is to be a single seat, twin-engine fighter armed with AIM-120A Advanced Medium Range Air-to-Air Missiles, AIM-9 Sidewinder missiles, and a 20 mm gun. It is expected to be able to fight in all types of weather, day or night, over land or sea, and at ranges greater than the current generation of fighters. The ATF design concept includes use of stealth technology, advanced materials, new engines capable of propelling the aircraft at supersonic speeds without afterburner, and an advanced highly integrated avionics system capable of detecting, identifying, and engaging the enemy at ranges beyond the pilot's vision.

Requirements

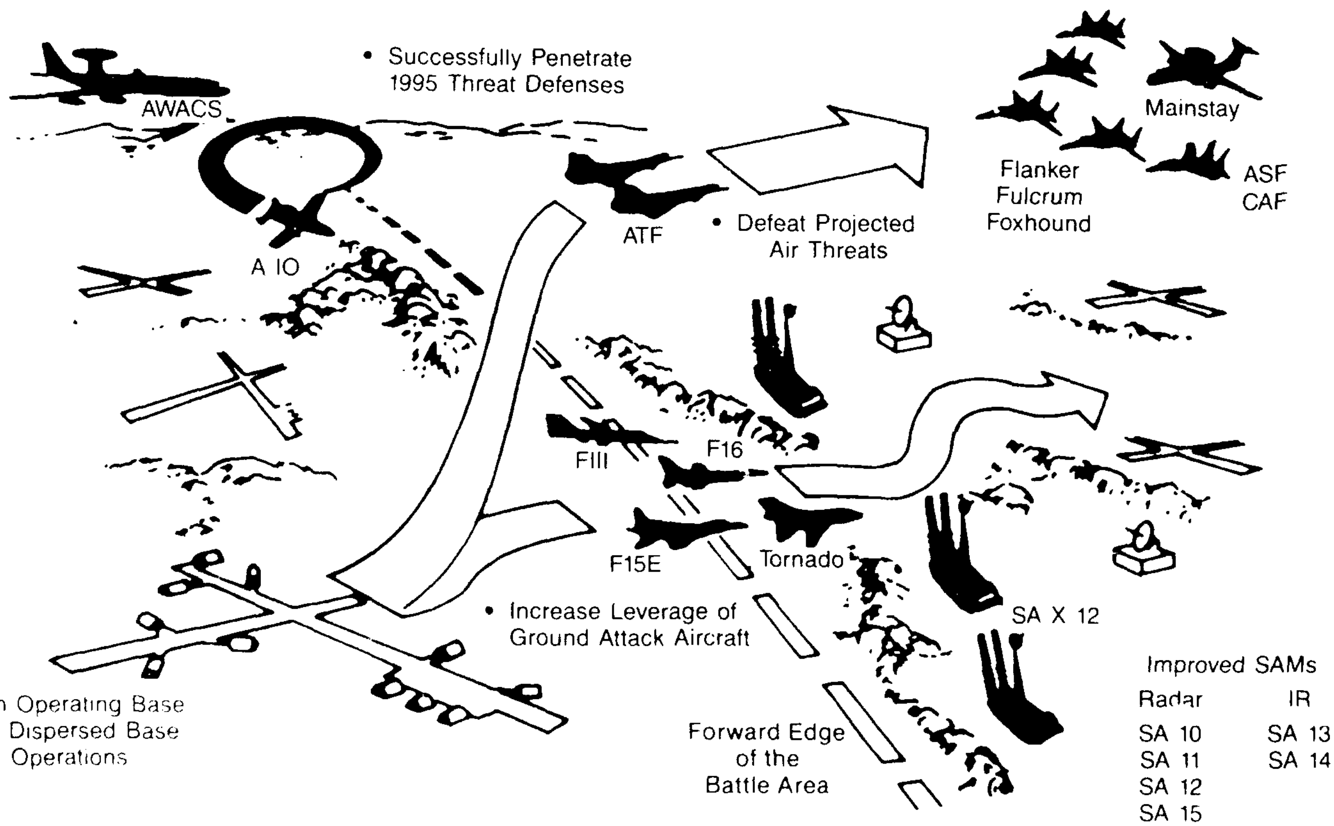
The Air Force considers the ATF to be its highest priority tactical research and development program. Some DOD officials believe that the ATF's promised technological capabilities are needed even now to counter the numerical advantage and growing effectiveness of Soviet threat systems. DOD recognized the need for an ATF in November 1981 and reaffirmed the need in an October 1986 Milestone I decision authorizing the Air Force to begin the demonstration/validation phase.

An Air Force analysis of the threat indicates a need for an air superiority fighter with advanced technologies and superior capabilities to counter the existing numerical advantage of Soviet and Warsaw Pact forces and the emergence of Soviet aircraft with capabilities equivalent to current U.S. fighters. In addition, Air Force-sponsored analyses have examined the need for air superiority and alternatives to achieve it, such as using ground-based air defense systems and/or upgrading existing fighter aircraft with many of the technologies planned for the ATF. These analyses not only affirmed the need for an advanced air superiority fighter but also considered both ground-based and airborne systems essential and complementary in the air defense mission. They show airborne fighters have greater mobility and flexibility to cover defensive gaps than other air defense systems, and they also augment ground-based air defense forces such as the Patriot and Hawk Missile Systems. Unlike relatively fixed-place ground-based defenses, airborne fighters can be deployed over large distances in short periods of time.

The analyses also indicate that in a conflict, more enemy aircraft would be destroyed by fighters than by ground-based air defense systems.

The Air Force also examined the effectiveness of modifying or enhancing versions of current fighter aircraft for airborne air defense. The results show that modifying the fighters would make them more effective, but improvements would be marginal relative to ATF capabilities. Also, the modified aircraft's survivability would be lower than the ATF's, thus requiring a greater number of such fighters to ensure air superiority in the mid-1990s and beyond. Figure III.3 shows an artist's conception of how the ATF would be used in offensive counterair.

Figure III.3: Artist's Conception of Dominate ATF 1995 Threat in Offensive Counterair



Schedule

The Air Force revised the ATF's acquisition plan in 1986 in response to a recommendation that new major weapon systems using new technology be prototyped.[4] That revision requires demonstration of prototypes in the demonstration and validation phase prior to selecting the winning design for full-scale development. While the schedule for demonstration and validation and for the start of full-scale development has basically remained unchanged since 1986, the remainder of the schedule was revised in May 1989 to accommodate President Bush's amended fiscal year 1990 budget. Table III.3 compares the ATF's 1986 schedule with the current May 1989 schedule.

Table III.3: ATF Schedule

Event	1986 schedule	May 1989 schedule	Month change
Demonstration/validation decision	Oct 1986	Oct 1986	
First flight of prototypes	Between Oct. 1989 and Mar 1990	Between Jan and Mar 1990	[illegible]
Full-scale development decision	Nov 1990 (9 aircraft)	Dec 1990 (9 aircraft)	[illegible]
Program management review	Not included	Dec 1993	[illegible]
Production lot 1 contract award[b]	Nov 1992 (18 aircraft)	Jan. 1994 (4 aircraft)	[illegible]
First flight of full-scale development aircraft, start of development test and evaluation	Nov 1992	June 1994	[illegible]
Low-rate initial production decision	Nov 1992	Dec 1994	[illegible]
Production lot 2 contract award	Nov 1993 (36 aircraft)	Jan 1995 (8 to 16 aircraft)	[illegible]
First flight of full-scale development aircraft with full avionics	June 1994	June 1995	[illegible]
Program management review	Not included	Dec. 1995	[illegible]
Production lot 3 contract award	Nov 1994 (48 aircraft)	Jan 1996 (32 aircraft)	[illegible]
Delivery of first production aircraft	Dec 1994	Feb 1996	[illegible]
Start of IOT&E	June 1995	May 1997	
Program management review	Not included	Dec 1996	[illegible]
Production lot 4 contract award	Nov 1995 (72 aircraft)	Jan 1997 (48 aircraft)	[illegible]
High rate production decision	Nov 1995	Dec 1997	[illegible]
Initial operational capability	Fiscal year 1996	To be determined	

[a]Completed

[b]The aircraft will be dedicated to Initial Operational Test and Evaluation

[c]Initial Operational Test and Evaluation

Although both schedules provide for concurrent development and production, the May 1989 schedule reduces the program's risk associated with concurrency. For example, the May 1989 schedule reduces the

[4]Made by the President's Blue Ribbon Commission on Defense Management

number of aircraft committed to production before the start of full-scale flight testing and before the flight testing of an aircraft with a full avionics suite and postpones the production commitment allowing additional time to develop and prove the more technically risky avionics.

If the 1986 schedule had been followed, both the contract award for the first production lot of 18 aircraft and the start of the full-scale development flight test program would have occurred in November 1992. Under the May 1989 schedule, the first production lot will be awarded 5 months before the start of flight testing, but only four aircraft, not 18, will be committed to production.

Both schedules provide for the award of the first and second production lots before an aircraft with a full avionics suite is flight tested, but the May 1989 schedule contains fewer aircraft. The 1986 schedule provides for a total of 54 aircraft in the first two lots, while the May 1989 schedule has a total of 12 to 20 aircraft in these lots, a reduction of 34 to 42 aircraft. Consequently, the current schedule lowers the risk associated with concurrency by reducing the number of early production aircraft. Furthermore, the May 1989 schedule delays the start of production by 14 months, from November 1992 to January 1994, allowing additional time to develop and prove the avionics.

Performance

ATF performance characteristics are stated as goals. Specific characteristics and performance thresholds will be established at the end of the demonstration and validation phase when the system specification for full-scale development is written.

Two competing contractor teams are each fabricating two prototype aircraft and two competing engine contractors are each fabricating and testing prototype engines. Each aircraft contractor team will flight test both engines.

Through January 1989, only computer modeling and component and sub-scale model wind tunnel testing had been performed on the ATF airframe. The flying prototypes will be the initial test resource for demonstrating the aerodynamic performance, flying and handling qualities, supersonic cruise speed, and engine compatibility with the airframe.

Through January 1989, the engine contractors had tested engine components and full-scale engines at simulated sea level and altitude conditions. Both engine designs require over 1,000 hours of ground testing before the engines are flight tested in the prototype aircraft.

The two aircraft contractor teams also are building avionics ground prototypes and flying avionics test beds that will be the primary resources to test the avionics functions during the demonstration and validation phase. The avionics ground prototypes are to demonstrate the system architecture, system software, integration of functions, modular packaging, cooling and built-in testing and diagnostics of each contractor's design through a series of demonstrations scheduled to end about mid-1990. The flying test beds are to confirm these ground demonstrations and to test the avionics sensors and apertures (e.g., the radar, infrared search, and track set and electronic countermeasures) further. Only limited avionics will be available for testing in the prototype aircraft.

Cost

As of May 1989 the program's total cost was estimated at $67.1 billion (escalated dollars). This estimate includes $3.3 billion for early development (including the concept exploration phase and the demonstration and validation phase), $10.2 billion for full-scale development, and $53.6 billion for procurement. The estimate for early development should remain stable because the demonstration and validation is covered by fixed-price contracts, whereas the estimates for full-scale development and procurement could change because contracts have not been issued.

The cost estimates for full-scale development and production were constructed using the analogous and parametric estimating methodologies. As actual cost and engineering data become available from producing the prototype articles and the configuration becomes defined, the Air Force anticipates an estimate with a greater level of confidence will become available.

The Air Force is using a unit flyaway cost goal to maintain cost discipline in the program. The goal is $35 million, stated in fiscal year 1985 dollars, and is being used as a benchmark to measure the probable production costs of various design alternatives. Achieving the desired ATF performance capabilities while remaining within the unit flyaway cost goal and the total estimated cost of $67.1 billion (escalated dollars) will be a challenge for the Air Force and the contractors because of the risks associated with technological advance.

Recent GAO Reports

Aircraft Development: The Advanced Tactical Fighter's Costs, Schedule, and Performance Goals (GAO/NSIAD-88-76, Jan. 13, 1988).

DOD Acquisition: Case Study of the Air Force Advanced Tactical Fighter Program (GAO/NSIAD-86-45S-12, Aug. 25, 1986).

Sensor Fuzed Weapon

The Sensor Fuzed Weapon (SFW) is a cluster-type weapon to provide a multiple kill per aircraft pass capability during day, night, and all weather conditions. The Air Force is developing it to attack formations of enemy armored vehicles.

In November 1985 the Air Force awarded a fixed-price incentive fee contract for full-scale development to Textron Defense Systems. Because of cost and schedule problems, the Air Force restructured the SFW program in June 1986 and established a cost and schedule baseline. Since the restructuring, the schedule for completing major milestones has slipped and the Air Force is restructuring the program again. Total acquisition costs are estimated at $3.2 billion (escalated dollars) for 19,900 units, but this estimate will likely increase when the restructuring is complete.

At the completion of our field work in June 1989, the program manager rated the SFW's progress toward meeting technical performance and cost baselines as "yellow" because of repeated test failures, technical problems, and schedule delays.[a] The program manager also rated the schedule as "red" or unachievable because technical problems had slowed delivery of test hardware, test failures had delayed approval of the system design, and the contractor was over budget and behind schedule. Also, in April 1989, the Air Force notified the contractor that it would consider terminating the contract unless the contractor provided a plan for correcting the problems.

Air Force officials said that tests conducted after the completion of our field work had been successful and that the contractor had provided an acceptable plan for addressing the problems. The Air Force stated that these events provide confidence that the major technical and management issues are now under control. Cost and schedule assessments will not change, however, until the program restructuring is complete and a revised acquisition program baseline is approved.

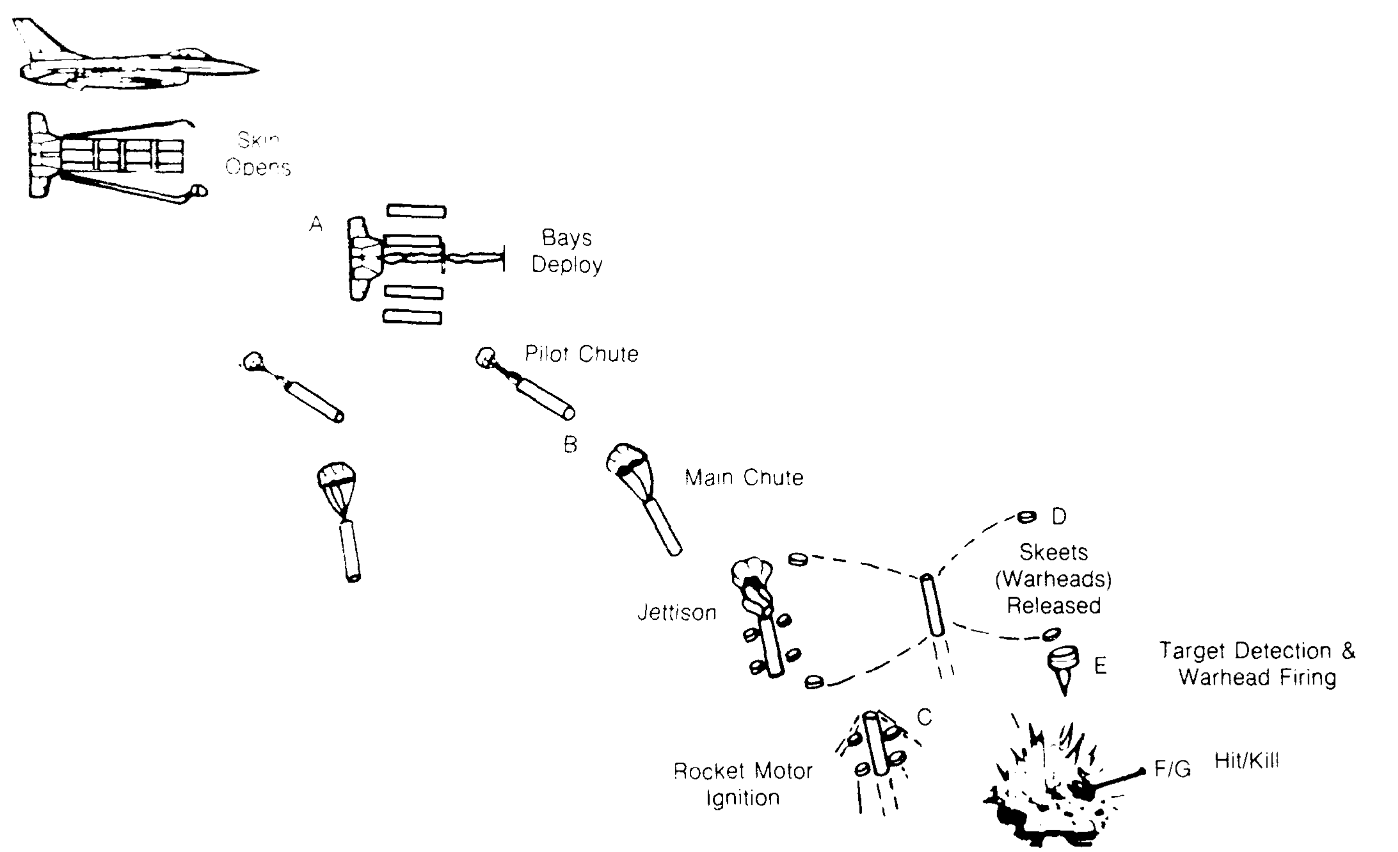
Background

The SFW will consist of a tactical munitions dispenser containing 10 submunitions. Each submunition will contain four individual warheads, or "skeets."

[a] A "yellow" rating means that there is a significant potential for not meeting the program performance parameters, cost thresholds, or schedule milestones.

The delivery aircraft will launch the dispenser upon reaching the target area. At a preset time or altitude, the dispenser will release the submunition launchers. Parachutes will deploy from the submunition launchers to stabilize their descent. At a predetermined distance from the ground, rocket motors will fire to elevate and spin the submunition to dispense the skeets. Once released, an infrared sensor in each of the warheads will scan the target area. When the sensor detects the heat of a vehicle, the skeet is to fire an armor-piercing penetrator into the target. Figure III.4 is an illustration of the SFW and its operational sequence.

Figure III.4: SFW Deployment Events



The SFW is to be compatible with several aircraft, including the F-15E, F-16, A-7, A-10, B-52, F-111, and several allied nations' aircraft. It will not replace any existing weapon system.

Requirements

The Air Force established the requirement for such a weapon in the late 1970s. A 1978 Air Force general operational requirement for wide area anti-armor munitions and a "U.S. Air Force Mission Element Need Statement," dated September 14, 1979, include the requirement for the SFW.

In May 1987 the Air Force Center for Studies and Analyses prepared an analysis to determine whether the SFW was a cost-effective weapon for attacking second echelon enemy armored formations. The Center concluded that the SFW would be considerably more effective against enemy armor formations than other alternatives—the Maverick missile, Combined Effects Munition, and 30-mm gun.

In May 1989 the Air Force approved a system operational requirements document for the SFW. It amplifies and refines the basic requirements document and explains how the proposed system will be operated.

Schedule

Since the development program baseline was established in June 1986, the schedule for completing major milestones has slipped. Table III.4 compares the latest approved schedule and the program manager's current estimate. The program manager's current schedule estimate has not been approved by all levels within the Air Force and DOD.

Table III.4: SFW Schedule Changes

Milestone	Approved program estimate (June 1986)	Current program estimate (Aug. 1989)	Schedule delay (months)
Full scale development contract award	Nov. 1985	Nov. 1985	
Critical design review	July 1987	Aug. 1989	25
Begin government development tests	Mar. 1988	Dec. 1988	9
Initial production decision	Nov. 1988	Aug. 1991	33
Production contract award	Dec. 1988	Dec. 1991	36
First delivery to inventory	July 1990	Dec. 1993	41

The schedule delays were caused by the nonavailability of development test and evaluation hardware, design changes, and test failures. These factors delayed completion of the critical design review,[a] which is crucial to completion of subsequent milestones, by over 2 years.

[a] The purpose of the critical design review is to determine if the design will satisfy performance requirements and meet development specifications.

Because of continuing test failures and missed milestones, the Air Force contracting officer notified Textron in April 1989 that development performance was not satisfactory and that the Air Force would consider terminating the contract for default if the situation were not remedied within 60 days. The contracting officer's letter cited consistent test failures and consistently underachieved schedules as reasons for the Air Force's concerns. According to the letter, nine consecutive test failures had occurred since October 1988. The schedule for completing the critical design review had changed three times. The critical design review was held in April 1988 but was not considered complete because contractor tests of multiple submunitions against multiple targets had not been successful. Also, according to the contracting officer's letter, hardware deliveries and test schedules had slipped several times and were in danger of slipping again due to frequent test failures.

The Air Force did not accept Textron's initial response to the contracting officer's letter because it did not provide a comprehensive plan of actions, initiatives, and commitments needed to put the program back on track. On June 9, 1989, Textron submitted a revised plan of action to address the problems, and the Air Force accepted the revised plan on June 19, 1989. At completion of our work in June 1989, the Air Force and Textron were continuing negotiations to rebaseline the contract.

Performance

Contractor subsystem tests have revealed a number of technical problems and the first two Air Force development tests failed. Because of these unresolved problems, at the completion of our work in June 1989, the program manager rated the SFW's technical performance as "yellow." However, preliminary reports provided by the Air Force showed that tests conducted after our field work was completed were successful.

Multiple submunitions drop tests conducted during 1988 showed that the detonation of one of the SFW warheads could cause the premature detonation of other nearby warheads, a phenomena known as "sympathetic firing." Textron made design changes to correct the problem and conducted additional tests using single warheads that were successful. However, a multiple submunition test in February 1989 showed that the problem was not resolved. In that test, 3 submunitions containing a total of 12 warheads were dropped from a cable in a specially prepared test area, but only one warhead hit a target.

The Air Force formed a team consisting of both government and industry representatives to conduct an independent technical review and determine the cause of the February 1989 test failure. The team concluded that the likely cause of the failure was the over sensitivity of the warheads' infrared sensors and the processor circuit. The sensors' processing logic likely reacted to extraneous signals from such things as debris and the explosion of other warheads, treating these as plausible targets. The contractor changed the sensor's sensitivity and made a repeat test in July 1989. During the test, three submunitions, each containing four projectiles, were dropped from a cable 300 feet above the ground. Each of the 12 projectiles detonated and 8 hit targets. A preliminary report provided by the Air Force considered this to be a successful test.

The first two development tests conducted by the Air Force were also unsuccessful. These tests were intended to demonstrate proper separation of the tactical munitions dispenser from the aircraft and the release of inert submunitions from the dispenser. During the first flight test, only 5 of the 10 submunitions deployed parachutes because an engineering error had caused needed circuits to be cut. This problem was identified and corrected; however, during the second test none of the submunitions were ejected from the dispenser because of a cracked component in the ejection electronics.

According to preliminary Air Force test reports, submunitions were successfully ejected in two development tests conducted in July 1989 after our review. In both tests, all 10 submunitions were ejected and all parachutes deployed properly. The first flight test of a complete SFW, with live submunitions, is scheduled for February 1990.

Cost

The SFW's estimated total acquisition cost has increased by $805 million since the June 1986 baseline cost estimate was established, primarily because the number of units to be procured increased from 14,084 to 19,900. Estimated unit cost has decreased from $171,000 to $161,000. Table III.5 shows the changes in the cost estimate.

Table III.5: SFW Acquisition Costs

[illegible]

Dollars in millions

Item	June 1986 estimate	Feb. 1988 estimate	Feb. 1989 estimate
Development	$128	$154	$180
Procurement	2,278	3,059	3,031
Total	**$2,406**	**$3,213**	**$3,211**
Quantities (thousands)a	14,084	19,978	19,900

aSeventy-eight test weapons were excluded from the current acquisition quantity.

The decrease from $3,213 million to $3,211 million was due primarily to a change in estimated inflation rates.

The current cost estimate does not reflect recent test failures and delays in the program. The Air Force plans to update its program cost estimate in September 1989, and the schedule delays and additional testing being considered for the restructured program will most likely increase estimated development and procurement costs.

Recent GAO Report

DOD Acquisition Programs: Status of Selected Systems (GAO/NSIAD-88-160, June 30, 1988)

Navstar Global Positioning System User Equipment

The Navstar Global Positioning System (GPS) is a space-based radio navigation system designed to provide precise, continuous, all-weather, common geographical coordinate system, world positioning navigation data, together with time and velocity information, for a multiplicity of military and civil users. The user equipment segment consists of one-channel, two channel, and two different five-channel radio receiver sets that will be deployed on approximately 200 types of aircraft, land vehicles, surface ships, and submarines.

The user equipment acquisition has been in the low-rate initial production phase since June 1986. The program has experienced delays in operational testing of low-rate production sets, resulting in a 15-month postponement of the full-rate production decision, from March 1989 to June 1990. The operational testing of the low-rate production sets in support of the upcoming full-rate production decision was scheduled for the third and fourth quarters of fiscal year 1989. This testing was to include evaluating whether GPS operational effectiveness or suitability problems identified during previous operational testing were corrected.

GPS testing will be limited to only 10 (about 5 percent) of the military platforms planned to receive the equipment. Air Force officials stated that while the number of test platforms is limited, additional data from other operational tests for other modifications involving GPS user equipment will be used and the combined testing data will cover 90 percent of the interfaces between GPS user equipment and other navigational and weapon systems.

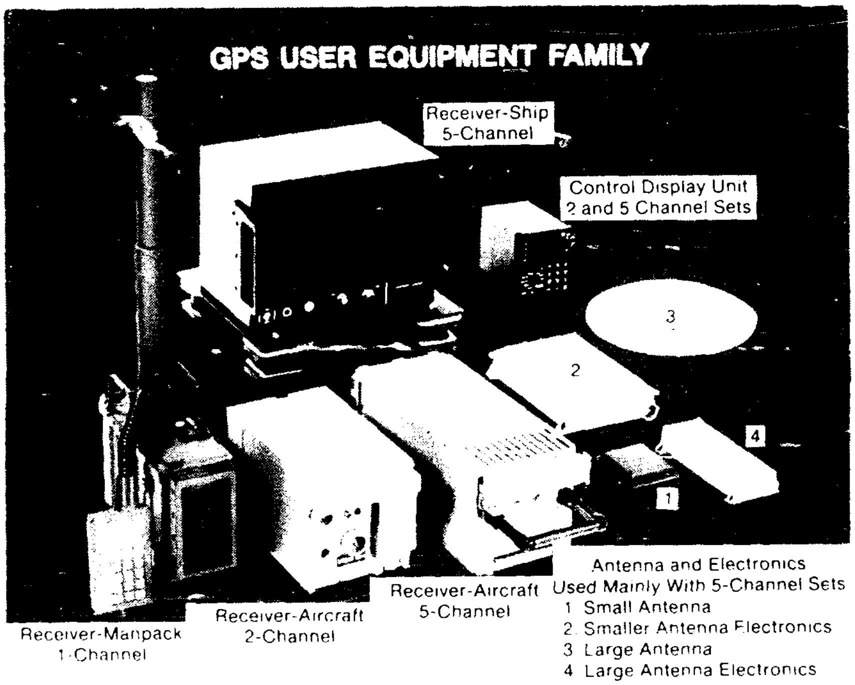
In the December 1988 SAR, the Air Force estimated total program costs for user equipment at $4.1 billion (escalated dollars) for about 25,500 sets. However, the SAR understates Navy and Marine Corps requirements for GPS user equipment by about 4,000 units, which resulted in understated procurement costs ranging from about $200 to $400 million.

Background

GPS consists of (1) a space segment, which when fully operational will consist of 21 satellites (plus 3 more orbiting satellite spares) in 6 orbital planes about 10,900 nautical miles above the earth, (2) a ground control segment consisting of a master control station, three ground antenna stations, and five monitoring stations, located in various parts of the world, to maintain control and accuracy of the spacecraft, and (3) a user equipment segment, which includes four types of radio receivers to convert satellite signals into navigation, time, and position information that the host vehicle can then convert into weapon delivery information. The

four types of receivers are (1) five-channel sets for high performance aircraft, (2) five-channel sets for ships and submarines, (3) two-channel sets for medium performance aircraft (e.g., helicopters), and (4) the Manpack/Vehicular set for hand-held and vehicle applications. (See fig. III.5.)

Figure III.5: GPS User Equipment Family



GPS is a joint Air Force, Army, and Navy program, with the Air Force designated as the executive service. The space segment is currently in full-rate production. The control system has been installed and is being prepared for turnover to Space Command.

Requirements

In October 1967 the Deputy Secretary of Defense asked the Joint Chiefs of Staff to review all navigation systems in use or being developed and to recommend the most cost-effective combination of systems. The resulting study identified a need for worldwide coverage, redundancy, instantaneous response, continuous availability, and ability to resist enemy countermeasures. It included accuracy requirements for en route

and objective area navigation in three dimensions (longitude, latitude, and altitude) for close air support, helicopter assault, mapping, electronic warfare, and bombing missions. The study found no system or combination of systems available in the 1970 to 1980 period to meet the requirements, and it stated that satellite systems appeared to have the most promise of providing continuous, worldwide navigational accuracy.

Even before the study, the Navy and the Air Force were developing separate satellite navigation systems. Following a memorandum issued by the Deputy Secretary of Defense on April 17, 1973, the separate efforts were combined. The memorandum designated the Air Force as the executive service to prepare plans for a satellite navigation system incorporating aspects of the services' separate systems.

The Deputy Secretary of Defense approved a system concept for development, designated the Navstar Global Positioning System, on December 22, 1973.

Schedule

The GPS user equipment acquisition entered the concept validation phase in 1973, full-scale development in 1979, and low-rate initial production in June 1986. Since we last reported on this system in April 1987, the full-rate production decision date has slipped 15 months, from March 1989 to June 1990. In addition, the planned completion date of operational field testing of the user equipment has slipped about 2 months. Table III.6 compares the Air Force's December 1986 schedule with its current program schedule for upcoming major events.

Table III.6: Upcoming GPS E Schedule Changes

Event	Dec. 1986 estimate	Dec. 1988 estimate	Months delayed
Production satellite launched	Oct 1988	Feb 1989	4
Operational field testing completed	Jun 1989	Aug 1989	2
Final operational test report		Apr 1990	
Full-rate production decision	Mar 1989	Jun 1990	15
GPS fully operational	Mar 1991	Mar 1993	24

The scheduled completion of operational testing slipped because of (1) late deliveries of low-rate production user equipment sets by the contractor and (2) delays in launching the first production satellite. Both the low-rate production receivers and one production satellite are needed to accomplish the operational testing program. The full rate

production decision was revised to accommodate changes in the testing schedule.

According to a joint program office contract official, the delay in delivering the low-rate production receivers occurred because the contractor experienced start-up and producibility problems. The official stated that the start-up problems were consistent with problems often encountered when a new production facility is first placed in operation and that the producibility problems included difficulties in assembling circuit boards. The official also stated that the program office expects the contractor to overcome these problems with no adverse impact on the current full-rate production decision date.

The first production satellite was successfully launched, using a Delta II expendable launch vehicle, on February 14, 1989. The 4-month postponement, from October 1988 to February 1989, was attributed to delays in getting the Delta II ready for the launch.

Under the current test plan, operational testing will cover about a 5-month period, from July through November 1989. Analysis and interim report preparation will take up to 90 days, and final reporting for a full-rate production decision will take another 60 days. Program officials expect the final test report to be submitted as currently scheduled on April 15, 1990. DOD requires that a final test report be submitted 45 days before the Defense Acquisition Board meets.

Program testing officials stated that they are confident that they will be able to accomplish the remaining development and operational testing and deliver the final test report in time for the June 1990 full-rate production decision.

Performance

The results of initial operational testing completed in fiscal year 1986 in support of the low-rate initial production decision for user equipment showed that the equipment generally met or exceeded requirements for position and navigation accuracy. However, the test and evaluation master plan, in summarizing these test results, rated the overall operational effectiveness of the test sets as marginal and operational suitability as unsatisfactory. Included in operational effectiveness is the ability of the user equipment to (1) integrate into various platforms and (2) function successfully with other systems aboard these platforms in their intended operational environments. Operational suitability relates to the reliability, maintainability, and availability of the user equipment.

The marginal rating for operational effectiveness resulted because user equipment operators or maintainers often had to use nonstandard procedures or corrective actions to compensate for problems with initializing[3] the sets or with integrating the sets with the host vehicles. Subsequently, the program office developed a master integration plan to standardize the planning and integration process, which is normally a 4- to 6-year effort. The plan requires a phased (plan, study, design, integrate, validate, and install) approach to the integration of user equipment on host platforms. The services have started the process on about 160 platforms and have completed integration and installation on 12 test platforms.

GPS operational suitability was unsatisfactory because for all host vehicles tested, user equipment failed to meet reliability and maintainability requirements. For example, a significant number of hardware and software failures resulted in reliability being well below test criteria. Maintainability did not meet user requirements because of unsatisfactory performance of the built-in test equipment. The program office has an ongoing program to improve user equipment suitability. This includes (1) an incentive agreement with the contractor to improve field reliability of production units and (2) a plan to improve the built-in test feature of the sets.

Limited development test results available as of February 1989 show improvements in user equipment reliability, availability, and maintainability. For example, laboratory test data show improvement in the user equipment's mean time between failure. Also, compatibility test results indicate that the built-in test equipment will detect and isolate a failure to the failed circuit board in accordance with contract requirements.

Operational testing of low-rate production sets to support the full-rate production decision was scheduled for the third and fourth quarters of fiscal year 1989. This testing was to evaluate whether the GPS operational effectiveness or suitability problems discovered during initial operational testing were corrected. Two of the stated objectives of the operational testing program were to evaluate whether user equipment (1) could be effectively integrated into a wide range of weapons platforms and function effectively in the operational environments of those platforms and (2) met the required reliability, availability, and maintainability criteria for the full-rate production decision.

[3] Initializing the set refers to the process of turning the set on and acquiring the satellite signal.

During operational testing, the low-rate production models will be evaluated on a limited number of platforms (10 out of about 200, or about 5 percent) scheduled to receive GPS production equipment. Air Force officials stated that although operational testing in direct support of the GPS program will include 10 platforms, operational testing conducted for other modifications will provide additional data on GPS user equipment interface performance. They stated that the combination of these tests will validate 90 percent of all possible interfaces between GPS user equipment and other platform navigation and weapons systems and that those interfaces not being tested are mostly included in the sets because of commonality of circuit card design and are not ever intended for use. The following table lists the platforms to be included in the GPS user equipment operational testing.

Table III.7: Platforms to Be Used During Operational Testing of GPS User Equipment

Air Force:	
[illegible]	Fighter aircraft
Navy:	
[illegible]	Antisubmarine warfare helicopter
[illegible]	Tank landing ship
[illegible]	Fast frigate
[illegible]	Guided-missile cruiser
[illegible]	Nuclear powered submarine
[illegible]	Light special warfare craft
Army:	
[illegible]	Troop transport helicopter
[illegible]	High Mobility Multi-purpose Wheeled Vehicle

The test plan for GPS user equipment does not document how and why these platforms were selected for testing. According to the joint program office, the 10 platforms were selected by the services and will span the range of dynamic conditions that the sets would experience in all operational platforms.

Cost

The Air Force currently estimates that the acquisition cost for user equipment will total $4.1 billion (escalated dollars). Table III.8 compares the Air Force's estimated costs and quantities for 1986, 1987, and 1988.

Table III.8: Changes to GPS User Equipment Costs and Quantities From 1986-88 (Escalated Dollars)

Dollars in millions

User equipment	Dec. 1986 estimate	Dec. 1987 estimate	Dec. 1988 estimate	Change
Research and development	$1,311.0	$1,274.8	$1,215.1	$-95.9
Operation and maintenance			62.8	62.8
Procurement	2,849.0	2,833.8	2,852.1	3.1
Total	**$4,160.0**	**$4,108.6**	**$4,130.0**	**$-30.0**
Quantities	27,339	27,042	25,579	-1,760

The current procurement estimate is based on updated cost estimates for host vehicle integration and current low rate production option prices adjusted for inflation and learning curves. The estimate also includes an amount for automatic price adjustments in the event that quantities change.

The $95.9 million research and development cost decrease resulted because the program office updated the estimated costs for integration of user equipment on various aircraft using actual contractor cost estimates.

Joint program office and Air Force officials stated that the $62.8 million for operations and maintenance represents estimated labor costs associated with installing user equipment on existing Air Force aircraft. According to these officials, before the December 31, 1988 SAR, they had included the $62.8 million in the procurement category. They transferred these costs to the operations and maintenance category to be consistent with the fiscal year 1990 President's budget, which included these costs as part of the operations and maintenance appropriation. However, the SAR does not clearly show or explain this transfer.

Reasons for the $3.1 million increase in procurement costs are summarized in table III.9.

Table III.9: Changes in Estimated GPS User Equipment Procurement Costs From 1986-88 Escalated Dollars

Dollars in millions

Change Associated With:	Costs
Delivery schedule and production rate changes	[illegible]
Procurement quantities changes	[illegible]
Support equipment and technical data requirements changes	[illegible]
Updated cost information for platform integration and [illegible] requirements	[illegible]
Transfer of GPS installation funds to operations and maintenance	[illegible]
Incorporation of contractor value engineering change proposal	[illegible]
Updated economic indices	[illegible]
Total	**$3.1**

The December 16, 1985, Conference Report (H. R. 99-443) instructs DOD not to develop any GPS user equipment, other than special use equipment, outside the sponsorship, direction, and coordination of the joint program office. The 25,579 GPS user sets reported in the 1988 SAR did not include about 4,000 units for the Navy and Marine Corps. On the basis of estimated user equipment costs provided by the program office, we calculate the cost of these units to range from $200 to $400 million. The 4,000 units include about 3,600 units for platforms that, according to the Navy, cannot accommodate the contractor's (Rockwell-Collins) five-channel design because of size and weight problems.

To solve the size and weight problems, the program office, along with the Army and the Navy, is developing alternatives to the Rockwell-Collins design. These alternatives include embedding the GPS function into existing navigation systems and procuring a smaller receiver, known as the 3/8-ATR Short. The program office estimates that the receiver should be available in fiscal year 1993 and embedded technology in fiscal year 1994.

Program officials agreed that about 1,700 of the 4,000 units should be included in the SAR but believe that the remaining 2,300 units associated with embedded technology should not be part of the SAR quantity, cost, and funding information. They cited an Assistant Secretary of Defense memorandum dated May 11, 1988, that states that upon obtaining a waiver from DOD, the services may initiate efforts to acquire special purpose user equipment, such as GPS-embedded sets. Further, program officials believe that this memorandum allows the Navy to acquire the GPS-embedded units outside the purview of the program office.

According to the program office, funding has been adequate in the past, but administration cuts in the fiscal year 1990/1991 request for GPS user equipment funds have reduced out-year funding to minimum levels. Program officials informed us that accomplishing all necessary efforts may result in the program dealing with unfunded requirements in the future, causing

- a 2-year delay in the development and operation of the Operational Reporting and Management System, which is intended to keep users informed of the operational status of GPS satellites and
- use of fiscal year 1989 funds originally budgeted for the Operational and Reporting and Management System in order to maintain fiscal year 1990 host vehicle integration requirements.

Recent GAO Reports

Satellite Acquisition: Global Positioning System Acquisition After Challenger's Accident (GAO/NSIAD-87-209BR, Sept. 30, 1987).

DOD Acquisition Programs: Status of Selected Systems (GAO/NSIAD-87-128, Apr. 2, 1987).

Tacit Rainbow

Tacit Rainbow is an Air Force-led joint program to develop an autonomous missile to help meet requirements to suppress enemy air defenses. Both air-launched and ground-launched versions are being developed and the two variants are at different stages in the acquisition process. The air-launched version is scheduled for a preproduction verification phase in fiscal year 1990 and the ground-launched version was scheduled for a full scale decision in the fourth quarter of fiscal year 1989.

Until recently, the Air Force and the Navy had planned to use the air-launched version, and the Air Force and Army had planned to use the ground-launched version. In December 1988, however, the Defense Acquisition Board approved an Air Force decision to drop out of the ground-launched program, and in April 1989 the Defense Resources Board approved a Navy decision to drop out of the air-launched program.

As a result of the Air Force's decision to drop out of the ground-launched program, DOD began reassessing defense suppression requirements and evaluating the Air Force's revised Tacit Rainbow strategy. Two potential candidates to meet some of these requirements are Seek Spinner and Harpy, both ground-launched defense suppression weapons. The Congress and the Secretary of Defense have expressed interest in Seek Spinner and Harpy, respectively. Seek Spinner is being tested by the Air Force, and in 1988 the Secretary of Defense directed that a foreign weapons evaluation be performed on Harpy. According to Air Force and Army officials, neither system meets service requirements because neither can be air launched and neither is compatible with the Army's launcher.

The air-launched Tacit Rainbow has experienced cost, schedule, and quality control problems that have delayed testing and assessing the missile's performance. Before the Navy withdrew from the program, its acquisition costs were estimated at $4,375.2 million (escalated dollars). President Bush's amended fiscal year 1990 budget estimate for Tacit Rainbow, which deleted the Navy funds, totaled $3,319.7 million (escalated dollars). Program acquisition costs for the ground-launched version are estimated at $1,607.5 million (escalated dollars).

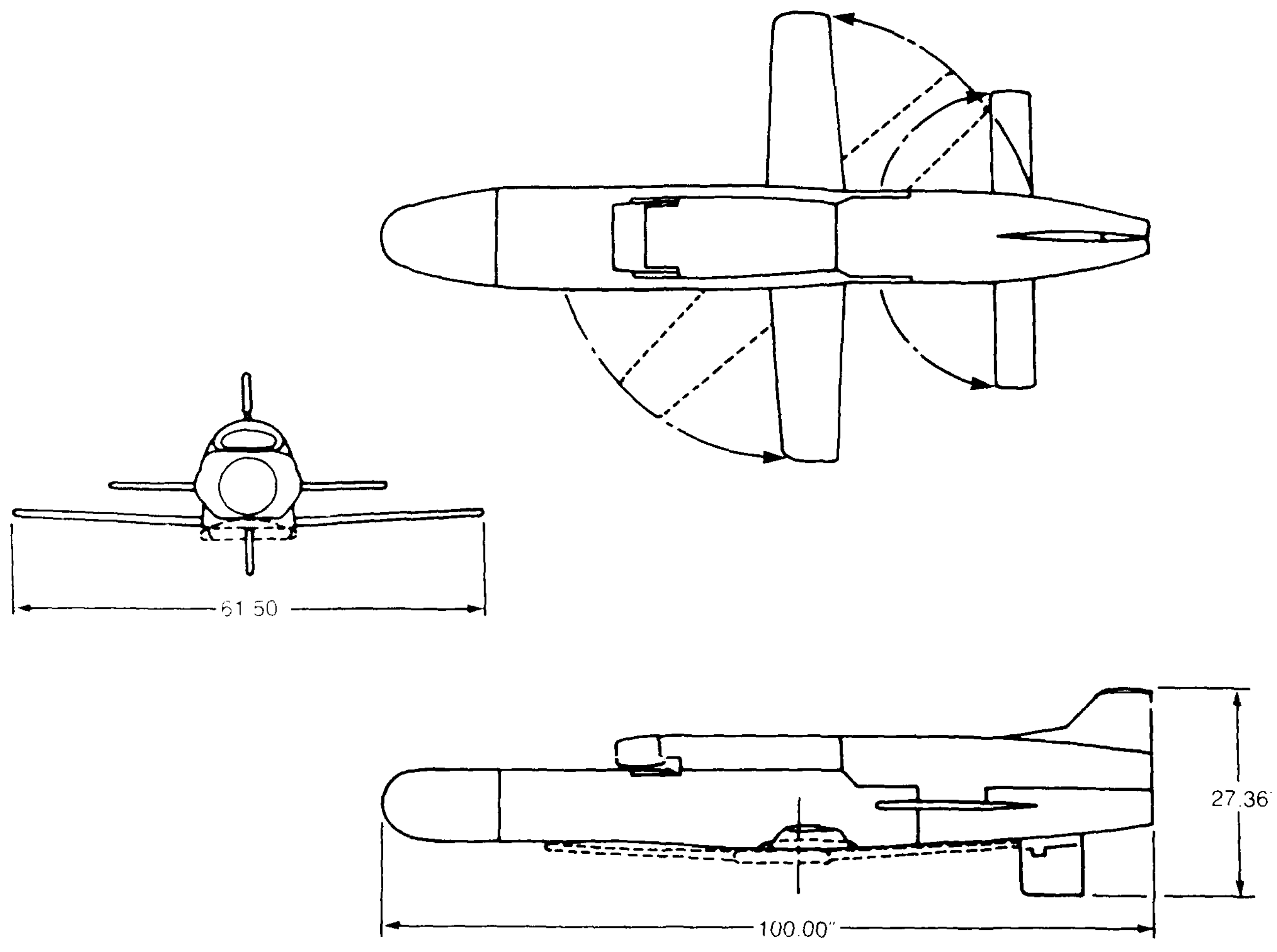
Background

Tacit Rainbow is intended to be a low cost, programmable-before-launch, attack missile system. It is to be capable of loitering in the target area while searching for and then attacking enemy radars to help suppress enemy air defenses. This new capability is intended to augment

manned defense suppression systems, such as the F-4G Wild Weasel the EF-111 aircraft. Tacit Rainbow will not replace any existing n is system.

The major missile components are the airframe, engine, target dete seeker, and warhead. While commonality is a goal of both versions some components will differ. As a minimum, the airframes will be d ferent because the ground-launched version must be compatible wit Army's Multiple Launch Rocket System. The Air Force intends to us the air-launched version with its B-52 aircraft. The air-launched Tac Rainbow is to be over 8 feet long and is to weigh about 440 pounds figure III.6). The ground-launched Tacit Rainbow development cont tor has not been selected yet, so similar design information is not av ble for this missile.

Figure III.6: Drawing of Tacit Rainbow (Air-Launched Version)



Originally a special access classified program, the air-launched Tacit Rainbow was initiated as a directed sole-source program and Northrop Corporation was awarded a full-scale development contract in October 1981. The program experienced cost, schedule, and technical problems that led to a 6-month risk reduction effort from July 1985 to January 1986. The full-scale development effort was resumed, but a services' cost cap of $160.6 million was imposed on the development contract with Northrop. Subsequent quality control problems delayed completing contractor development flight testing and caused the Air Force to restructure the program by adding a preproduction verification phase and delaying the low-rate initial production decision until late fiscal year 1990.

In 1984 DOD terminated the Seek Spinner development program, a ground-launched system with similar mission capabilities, and directed the services to proceed with a joint Tacit Rainbow program. The Air Force was designated as the executive service for Tacit Rainbow. Because the Air Force and Navy were participating in the air-launched program, the Air Force and Army began to develop a ground-launched Tacit Rainbow system.

In 1988 the Air Force awarded three teams of contractors (Northrop is the leader of one team) contracts to perform trade-off studies for the ground-launched version. It also asked the contractors to submit proposals to become a second source for the air-launched version. Should Northrop be selected as the ground-launched contractor, another contractor would have to be selected to become the second source for the air-launched version. In April 1989 the source selection process began for the ground-launched Tacit Rainbow's full-scale development and for the air-launched version's second source. The selection process was scheduled to be complete in August 1989 and the resulting contracts were to be awarded in September 1989.

Requirements

In May 1985 the Air Force, Army, and Navy approved a Tacit Rainbow Joint Service Operational Requirement. This requirement was updated in December 1988 to reflect program changes, such as the Air Force's decision to use only the air-launched version. The Air Force also decided to use only the B-52 aircraft to launch the missile, deleting the EF-111 and F-16 aircraft it had planned to use as launch platforms. According to Air Force officials, an initial study indicated that the air-launched Tacit Rainbow's operational requirements could be met by the B-52 force structure. This would enable full use of the F-16s to carry other

weapons. According to DOD, it completed its study of defense suppression requirements for use in evaluating the Air Force's revised strategy concerning Tacit Rainbow in July 1989. Seek Spinner and Harpy are potential candidates to satisfy some of the defense suppression needs, although the services believe neither system meets their requirements. As directed and funded by the Congress, in 1987 DOD reinstituted development efforts on Seek Spinner, which is currently being tested by the Air Force. The Congress appropriated an additional $20 million in fiscal 1989 funds for Seek Spinner; however, the fiscal year 1989 Authorization Act specifically prohibits any obligations for Seek Spinner with fiscal year 1989 or later funds. As of June 1989, the Congress had not authorized expenditure of these funds. Additionally, in 1988 the Secretary of Defense directed that a foreign weapons evaluation be performed on the Israeli-built Harpy defense suppression system. Harpy is similar to Seek Spinner in design and employment concept.

Schedule

In December 1988 the Air Force revised the air-launched version schedule when it restructured the program as a result of delays in completing contractor development testing. The initial low-rate production decision was delayed about 1 year, to the fourth quarter of fiscal year 1990. A new program decision point was added—approval of a preproduction verification phase—and scheduled for the fourth quarter of fiscal year 1989. Preproduction verification is to be a transition to the initial low-rate production phase and is intended to

- "line proof" the new production facility by demonstrating and verifying the production processes and facilities,
- produce 90 missiles as test assets,
- preserve the follow-on operational test schedule, and
- preserve the vendor base.

The decision to initiate the preproduction verification phase is to be based on demonstrating Air Force developed success criteria during the first 8 shots of tl e 25-shot combined development and initial operational test phase. The 25-shot test program is scheduled to take about 15 months. The initial low-rate production decision is to be based on successfully completing the entire test program. Subsequent to the program restructure in December 1988, the initiation of this test program was delayed about 2 months, with the first test occurring in March 1989. Two more tests had occurred by the end of May 1989.

According to Air Force officials, the Navy's withdrawal from the air-launched Tacit Rainbow procurement program resulted in a further schedule change. Table III.10 compares the schedule as revised May 1, 1989, with the December 1988 program restructure and the Tacit Rainbow December 1987 SAR schedules.

Table III.10: Air-Launched Tacit Rainbow Schedule

Event	Dec. 1987 schedule	Dec. 1988 schedule	May 1989 schedule
Preproduction verification (contract award)	Not included	Sept 1989	Nov 1989
Initial low-rate production decision	June 1989	Aug 1990	1st quarter 1991
Full-rate production decision	Not shown	1st quarter FY 1993	1st quarter FY 1993
Initial operational capability		Classified	

The ground-launched version program is nearing initiation of full- scale development. The three teams of contractors, which participated in the weapons design studies, are now competing in this version's full-scale development source selection. Table III.11 shows the ground-launched Tacit Rainbow schedule as of June 1989.

Table III.11: Ground-Launched Tacit Rainbow Schedule

Event	June 1989 Schedule
Full-scale development contract award	September 1989
Initial low-rate production decision	1st quarter 1993
Full-rate production decision	1st quarter 1995
Initial operational capability	Classified

Performance

DOD cannot accurately assess the air-launched version's ability to meet its performance requirements until sufficient testing is completed. As of May 31, 1989, 3 shots of the 25-shot combined developmental and initial operational test program had occurred. Detailed performance results for these initial tests were not available at the time we completed our review. According to the May 1, 1989, program schedule, the 25-shot test program is to be completed in September 1990, in time to serve as the basis for the initial low-rate production decision. Further operational testing of production configured missiles is required before approving full-rate production. This testing is scheduled to be complete in late fiscal year 1992.

While the contractor developmental testing encountered numerous problems and delays that led to the program restructure, the Air Force concluded that the feasibility of the basic design had been shown by the one completely successful flight test. Additional seeker testing using a manned aircraft also provided positive results, according to the Air Force.

The ground-launched Tacit Rainbow is not scheduled to begin service testing until the end of fiscal year 1991. At that time, the Air Force will begin to assess the missile's performance.

Cost

The Air Force's cost estimate for air-launched Tacit Rainbow shown in the December 31, 1988, Tacit Rainbow SAR is $4,375.2 million (escalated dollars). This includes $169.1 million for research and development and $4,206.1 million for missile procurement, aircraft modifications, and military construction. Excluded from this estimate are funds prior to fiscal year 1988 because that information is still classified. This estimate is $650.1 million more than the estimate shown in the December 31, 1987, Tacit Rainbow SAR. The major changes to the cost estimate are shown in table III.12.

Table III.12: Changes in Air-Launched Tacit Rainbow Cost Estimate (Escalated Dollars)

Dollars in millions

Change	Amount
Increases	
Increased procurement quantities	$117 0
Delays, lower production rates, and extensions in missile production	294 0
Program content changes, such as seeker enhancements or changes from government to contractor provided components	532 0
Estimate refinements	147 5
Total increases	**$1,090.5**
Decreases	
Lower estimated escalation factors	$−33 8
Estimated savings from using second source competition	−197 0
Revised estimate for some logistics needs	−125 7
Refined cost estimate for missile launcher	−83 9
Total decreases	**$−440.4**
Net program increase	**$650.1**

In April 1989 the Defense Resources Board approved the Navy's decision to delete its air-launched Tacit Rainbow procurement funding for

fiscal year 1990 and beyond. The amended fiscal year 1990 budget total program estimate for air-launched Tacit Rainbow totaled $3,319.7 million (escalated dollars), a reduction of $1,055.5 million. The estimate includes $165.2 million for research and development and $3,154.5 million for procurement of missiles, aircraft modifications, and military construction. According to Air Force officials, the Navy's withdrawal will require development of a new total program budget.

The ground-launched Tacit Rainbow program acquisition cost is estimated at $1,607.5 million (escalated dollars). This includes $328.6 million for research and development and $1,278.9 million for procurement.

Recent GAO Reports

No unclassified reports.

Major Contributors to This Report

Alice H. Spargo, Project Manager, NSIAD
Pauline F. Nowak, Deputy Project Manager, NSIAD

Army Programs

MLRS TGW and AAWS-H

Raymond Dunham, Assistant Director, NSIAD
Thomas W. Gilliam, Regional Management Representative, Atlanta Regional Office
William S. Lipscomb, Evaluator, Atlanta Regional Office
Mark A. Lambert, Evaluator, Atlanta Regional Office
Carol T. Mebane, Evaluator, Atlanta Regional Office

LHX

F. James Shafer, Assistant Director, NSIAD
Paul L. Francis, Evaluator, NSIAD
James S. Moores, Regional Management Representative, Kansas City Regional Office

LOS-F-H

Raymond Dunham, Assistant Director, NSIAD
William K. Newman, Evaluator, NSIAD
George H. Shelton, Evaluator, NSIAD

Navy Programs

RAM

Richard J. Herley, Assistant Director, NSIAD
Patricia M. Riggle, Evaluator, NSIAD

V-22

Clifford W. Martin, Regional Management Representative, Philadelphia Regional Office
Richard E. Schultz, Evaluator, Philadelphia Regional Office
John D. Heere, Evaluator, Philadelphia Regional Office
Anne-Marie Lasowski, Evaluator, Philadelphia Regional Office

Sea Lance	John J. D'Esopo, Assistant Director, NSIAD Paul J. O'Brien, Evaluator, NSIAD Debra L. Logan, Evaluator, NSIAD
AN/BSY-1	Frederick A. Bigden, Assistant Director, NSIAD Frances W. Scott, Evaluator, NSIAD James B. Dowd, Evaluator, NSIAD

Air Force Programs

Peacekeeper Rail Garrison	Steven F. Kuhta, Assistant Director, NSIAD John J. Klotz, Evaluator, NSIAD Gary W. Kunkle, Evaluator, Los Angeles Regional Office
ATF	Robert L. Pelletier, Assistant Director, NSIAD Robert D. Murphy, Regional Management Representative, Cincinnati Regional Office James R. Kahmann, Evaluator, Cincinnati Regional Office Neilson S. Wickliffe, Evaluator, Cincinnati Regional Office
SFW	Robert L. Pelletier, Assistant Director, NSIAD Jimmy R. Rose, Evaluator, Atlanta Regional Office Muriel J. Castillo, Evaluator, Atlanta Regional Office
Navstar GPS User Equipment	Gary Weeter, Assistant Director, NSIAD Danny M. Bullock, Regional Management Representative, Los Angeles Regional Office Noel J. Lance, Evaluator, Los Angeles Regional Office Calvin J. Durham, Evaluator, Los Angeles Regional Office Hilary C. Sullivan, Evaluator, Los Angeles Regional Office
Tacit Rainbow	Terry R. Parker, Evaluator, Cincinnati Regional Office Terrell L. Bishop, Evaluator, Cincinnati Regional Office